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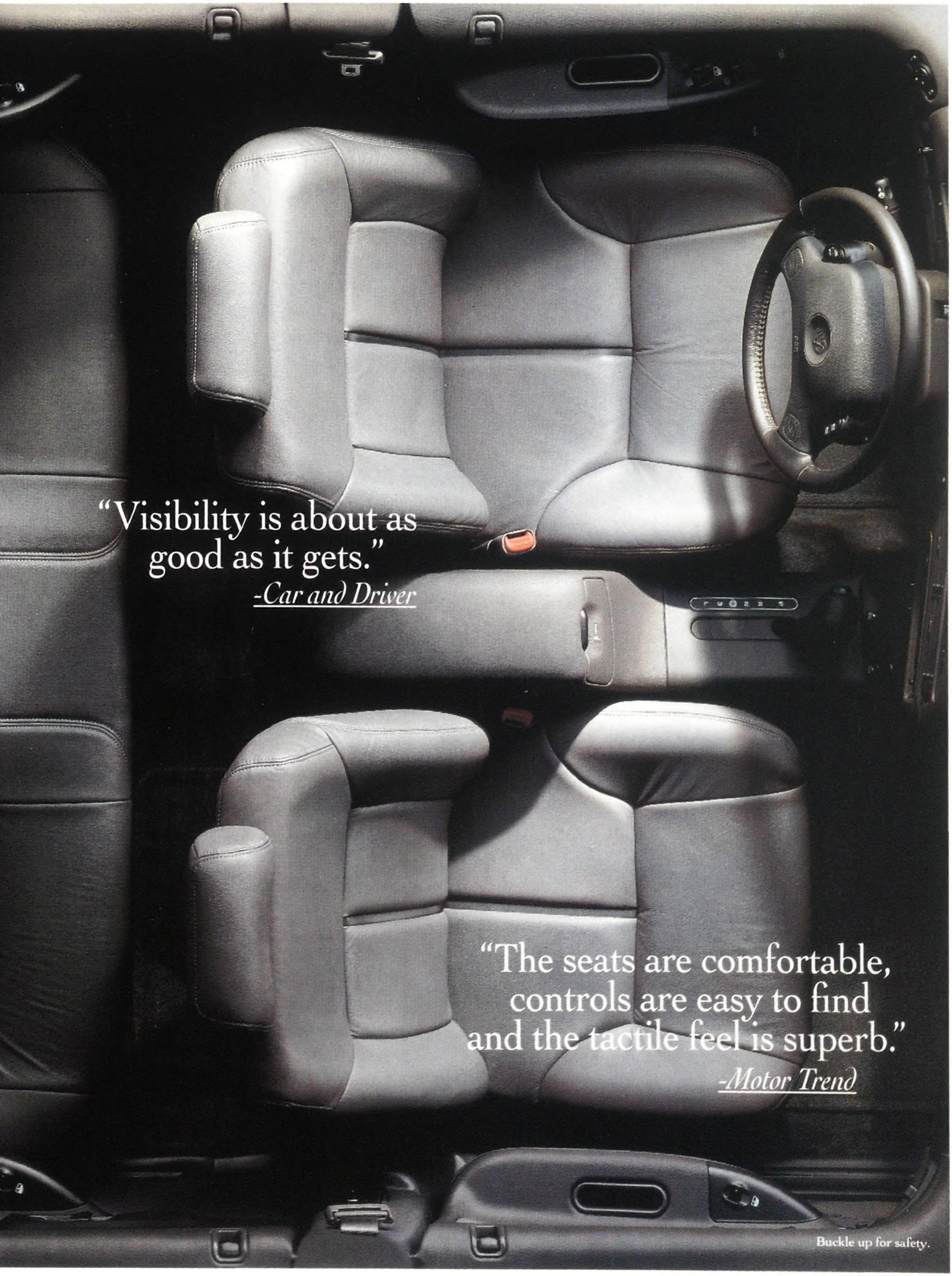
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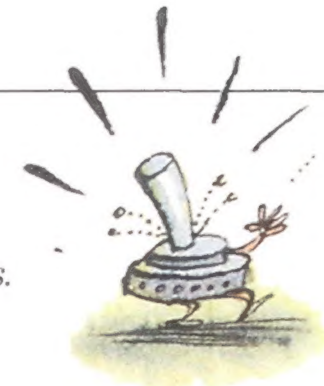

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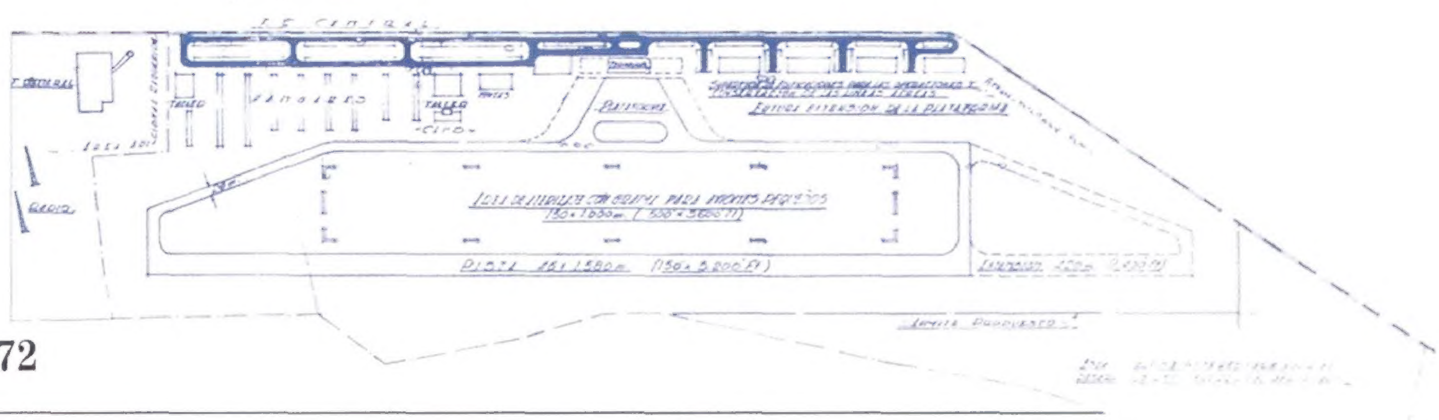

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Cover: *Chad Slattery photographed former X-15 pilot Milt Thompson and a replica of his craft at Edwards Air Force Base.*

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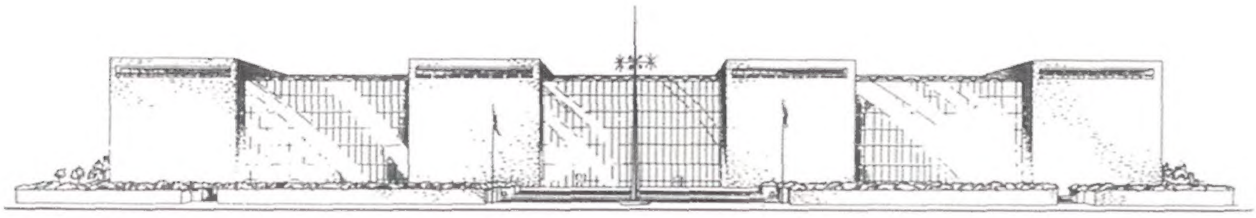
VIEWPORT



Shoulders of Giants

Looking at space exploration today, many express dismay at the apparently slow pace. Nothing compares in excitement to the heady days of Apollo in the 1960s.

Is ours an era of real malaise or is this perception largely untrue?

Time and again our robotic spacecraft have visited planets never visited before, sending back panoramas of unimaginable landscapes. Time and again powerful telescopes, capable of sensing radiation unperceived by the human eye, have conveyed new views of the universe that take us back in time to an era of creation and explosive eruption. Time and again, we have looked down from orbit and discovered an Earth that we had not understood or appreciated.

Those are no small achievements, and they have been made possible only through near-miraculous inventiveness and applications of technology.

Still, the general public seems to expect greater miracles—miracles still undefined, but clearly understood to be noticeably absent.

What might those miracles be? At least a manned trip to Mars, for starters. Anything less than that we've already done. And while we are at it, why should Mars be such a stretch when we've already been to the moon? No, something really miraculous would be more like a manned trip to the stars. Now, wouldn't *that* be something!

The trouble with such expectations is that they overlook the infrastructure on which the Apollo program was built.

Looking back in his old age on all his accomplishments, Isaac Newton was able to write, "If I have seen further than [others] it is because I stood on the shoulders of giants."

The Apollo program also had shoulders to stand on—technological shoulders. When the program began, we had nearly two decades of experience in rocketry and space navigation. It had begun with the German V-2 program in the early 1940s. After the war, the United States had shipped from Germany enough parts to construct some 100 V-2s. Also brought over were Wernher von Braun and his colleagues from Peenemünde, who worked with our military to help us understand the technology the Germans had spent years launching. In the 1950s we went to intercontinental ballistic missiles, with their powerful rocket motors, computer brains, and sensitive inertial guidance systems.

So the Space Age did not arrive as an isolated phenomenon out of nowhere. It came because we had experimented with a wide variety of chemical fuels, developed a range of communications systems, invented a selection of lightweight materials, and gained an understanding of reentry technology.

The technological shoulders were there, though we had to learn to stand on them.

Today's problem is different. Having gone as far as we did in the Apollo program, we must now spend several decades building a new, higher infrastructure plateau.

While slowly building up that base, we are also turning new technologies to good use—learning how the universe evolved; charting the solar system with its comets, asteroids, moons, and planets; and gaining insight into environmental processes right here on Earth.

But there's still the need for more powerful engines, far more affordable launch costs, micro-miniaturization of bulky parts, studies of human physiology and psychology that would benefit future manned explorations, a consensus on the ecological issues that would arise if we landed on other worlds, and a spate of other requirements for a new, advanced infrastructure on which to build.

We may not be able to produce more miracles in space just now, or go that much further than previous generations, but providing the shoulders that future generations will stand on is an honest undertaking. Let's not belittle it.

—Martin Harwit is the director of the National Air and Space Museum.

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LETTERS

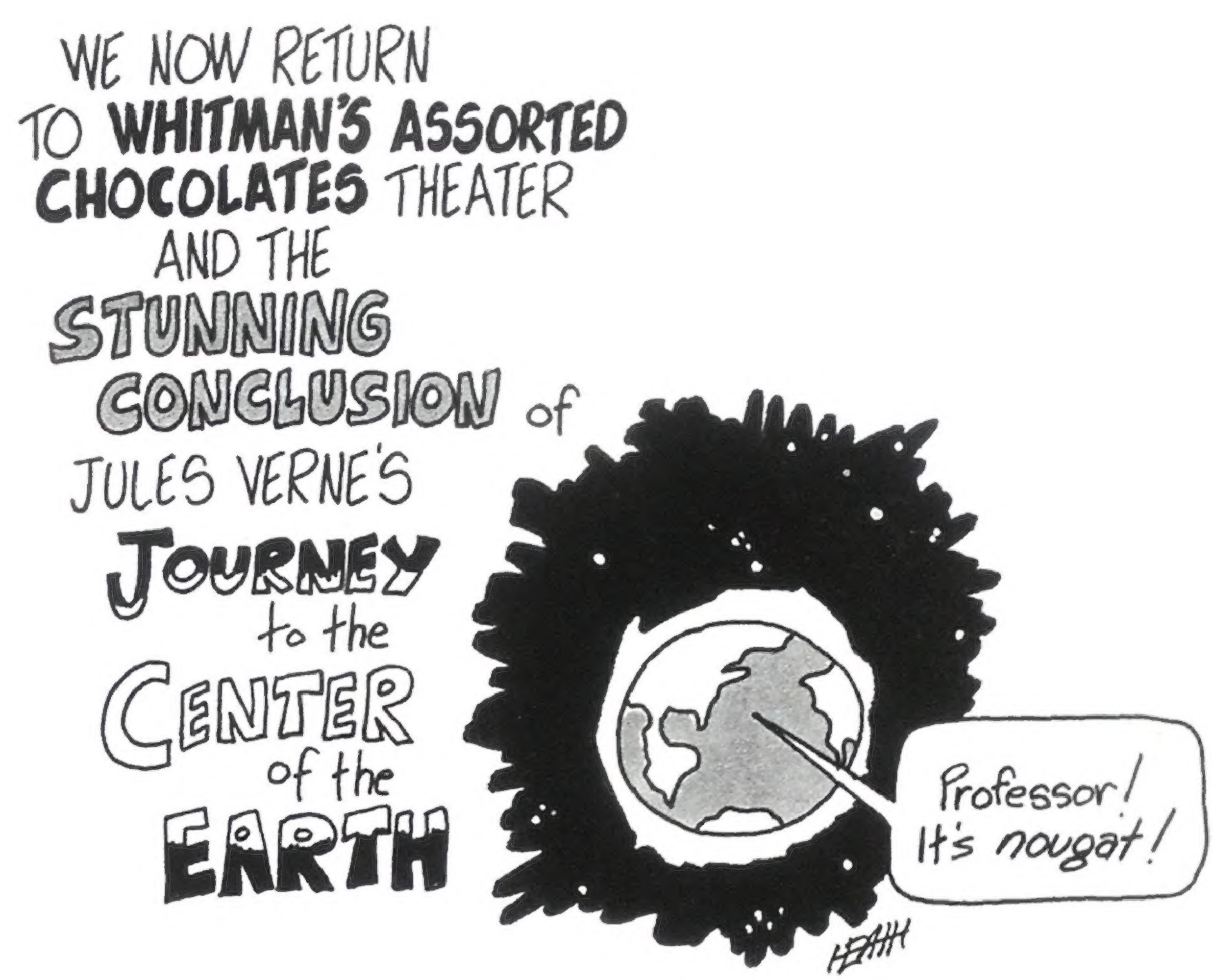
Star Trek: The Real Experience

Although "Star Trek: The Final Curtain" (April/May 1993) accurately presents our experiences as volunteers at the National Air and Space Museum's Star Trek exhibit, the article neglects to convey the real essence of the time we spent volunteering. I believe I speak for the majority of my nearly 300 fellow volunteers when I say that what we will remember are the large numbers of visitors who were simply wonderful—not the few people who may have had reason to complain. We will remember Jim, a severely handicapped yet mentally astute teenager whose joy at being in the gallery moved us. There was also the president of Mozambique, who stood in line with everyone else to sign the guest book, and the many other foreign guests whose smiles and nods conveyed what their words could not. We'll also remember the man who named all of his children after the crew of the starship *Enterprise*. Truly, each and every visitor was special.

Sure, some days went more smoothly than others, and the nerves of both the volunteers and the visitors were sometimes strained. I often joked about sitting in the Museum lobby answering hundreds of questions, but nothing saddened me more than having to turn people away. All of the volunteers did their best to accommodate as many people as possible, keeping in mind the safety and welfare of our guests.

It distresses me to think that your readers, many of whom may have visited the exhibit, would get the impression that we saw them as irritants. Our happy stories far outweigh the negative ones, and it was a pleasure and a privilege to meet many of the nearly one million visitors who passed our way. It was an experience we will never forget.

Marilyn E. Kozak
Springfield, Virginia



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Who Was Charles Lindbergh?

It fascinates me that William H. Honan, in his review of Joyce Milton's *Loss of Eden: A Biography of Charles and Anne Morrow Lindbergh* (April/May 1993), suggests that Lindbergh's 1927 flight wasn't so difficult after all. That idea tells you more about Honan than it does about Lindbergh. It is also sad that Lindbergh's travels to Germany in the 1930s are so misrepresented. He went to Germany because the American government wanted him to find out as much as possible about German military aviation. He did not go because he was flirting with Nazism. Whether he was successful in helping American intelligence is another issue, but it is outrageous that Lindbergh's motives have been so completely distorted.

Richard A. Young
New York, New York

Contrary to Joyce Milton's characterization, Charles Lindbergh was in no way "ludicrous." Certainly Lindbergh, in his support for American isolationism at the start of World War II, misunderstood the nature of Nazi totalitarianism and its danger to the rest of the world. History proved his judgment wrong in this respect. However, his views were shared by millions of Americans who were just as anxious for the United States to avoid involvement in a world war. Those millions have the advantage of being protected by anonymity from the two-pronged attack of an obviously biased biographer and an equally unsympathetic reviewer.

Cameron Richardson
New York, New York

The Day of the Condor

"The Condor and Me" by Louis Arata (Above & Beyond, April/May 1993) brought back memories of my first-ever flight, which I made in that huge bird on my 14th birthday. Clarence Chamberlin flew out of a tiny field in Bennings, Maryland, just across the Anacostia River from Washington, D.C. In those days, there must not have been any no-fly zones over the city, for Chamberlin delighted his passengers with pylon turns over both the Capitol and the White House. He also heartily amused us with such quips as "Dancing on the upper wing only, please!" What an introduction to the world of flight.

Frank Nelson
Newark, Delaware

In Defense of My Grandfather

I read with interest "Gentlemen, I Give You the Whittle Engine" (October/November 1992). However, I must take exception to several statements about my grandfather, General Hap Arnold. I wondered what camp author Daniel Ford represented, and when I checked his credits in the back of the issue, I found out. While I have not read his book *Flying Tigers: Claire Chennault and the American Volunteer Group*, I know from my wide reading of primary and secondary sources on General Arnold, his commanders, and the air war that by the 1940s Arnold and Chennault had been at odds for years. I suspect that Daniel Ford has taken up the case for Chennault.

The first misdirection in the article is the implication that the sole reason Hap Arnold traveled to Great Britain in 1941 was to "get at" British technology. This is not true. He was after firsthand knowledge about the performance of U.S. planes and the success of British bomber tactics.

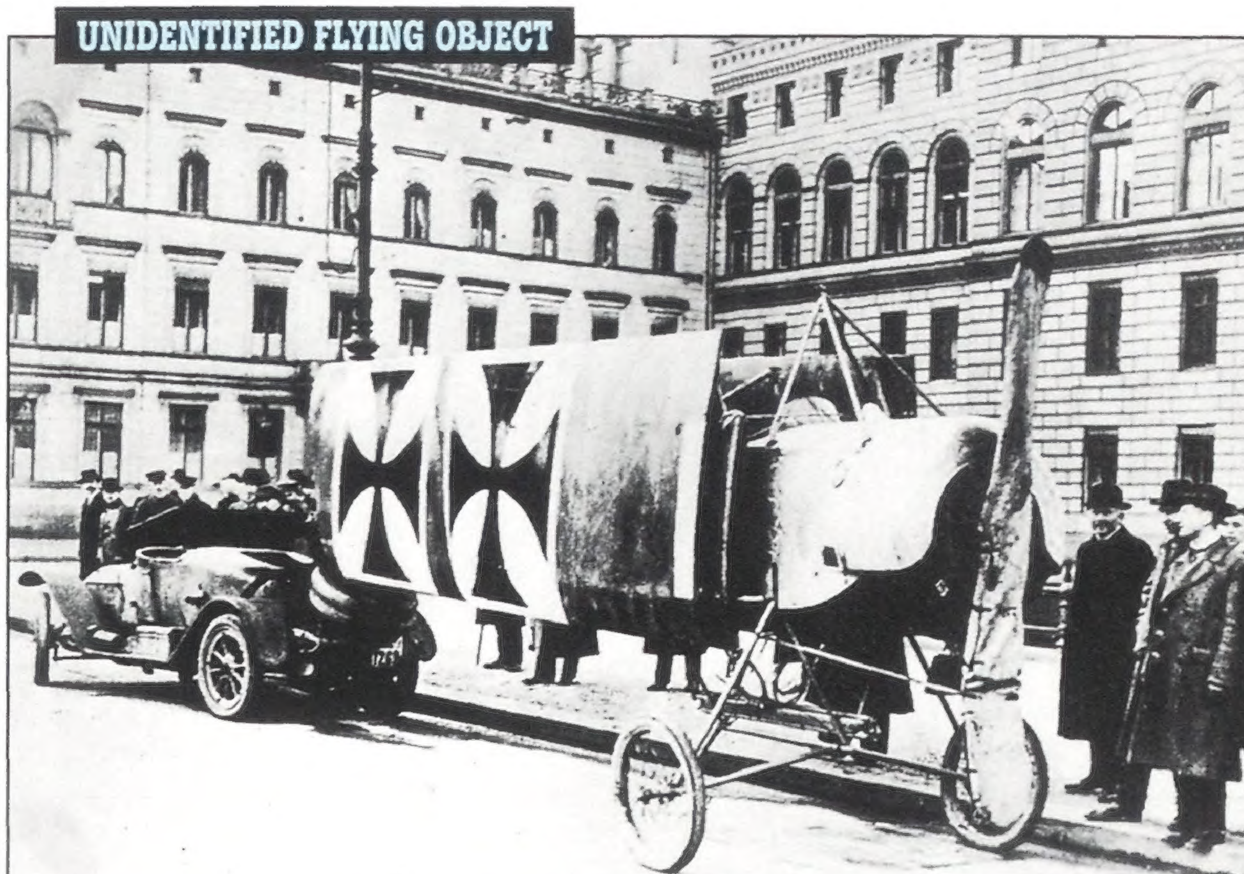
Ford also gives a list of Hap Arnold's liabilities and assets. Let me add a few items to his list of pluses and dispute Ford's list of minuses.

(1) Hap Arnold had a detailed understanding of the U.S. industrial base's aircraft design and manufacture capability that dated back to 1917.

(2) By 1941 Hap Arnold had been flying for 30 years. He had flown thousands of hours in almost every type of aircraft that the U.S. Army had purchased over those 30 years. Most agree that he was a pretty good and very experienced pilot.

(3) Forget the West Point ring. One of his major assets was the total confidence that General George C. Marshall (who wore a Virginia Military Institute ring) had in him. In fact, Hap Arnold had been at terrible odds with the West Point graduates of the General Staff for years.

UNIDENTIFIED FLYING OBJECT



Can you identify the aircraft in this photograph? From time to time the National Air and Space Museum's archives division receives photos that its staff cannot identify. They would appreciate any help in determining why this World War I-era Fokker E III-type single-seater is twice marked with the German national insignia. And why does the brace in front of the cockpit windscreen have four supporting members rather than the usual two? The original photograph has the notation "Volume II—267 Photograph from Official German Government War Collection—1918." If you can solve the mystery, send your response to: Air & Space/Smithsonian, *Department ASP, 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.*

Four of our readers—H.H. Christensen, Grahame K. Gates, Frank S. Mann, and Brian Riddle—correctly identified last issue's Unidentified Flying Object as a Bodmin biplane. Manufactured by the British company Boulton & Paul, the Bodmin was a mailplane powered by two Napier Lion engines.

His next asset was the confidence that President Franklin Roosevelt had in him. Arnold focused on winning the war. The job of increasing the Army Air Forces from 20,000 men and officers (pre-war) to 2.5 million by 1944 required special skills. Hap Arnold had those skills and George Marshall knew it.

(4) What is a "good executive"? Many a good executive would never have stuck his neck out and set up the training school system, which produced tens of thousands of pilots years before a standard approach would. A good executive might never have taken the personal risks for the B-29 and other projects. Sure, he had a famous temper, but Hap Arnold got the job done.

(5) Hap Arnold had the knack of seeing the possibilities of technology in the blink of an eye. He was comfortable with civilian scientists, while other military leaders of his time were not. He was also flexible: when a cherished idea of his was proven wrong, he would turn on a dime and move forward. But you did have to prove your point.

(6) As to Hap Arnold's lack of combat experience, of course he wasn't a combat pilot. He wanted to be one in the worst way. In World War I, the only chance he would have, he finally got himself over to France in 1918. Ill with the flu, he reached the front just in time for the November 11 armistice. Let's be clear here: any implications that Hap Arnold was just another rear-echelon desk pilot of questionable fortitude is untrue.

Robert Arnold
Sonoma, California

Early crop duster

Daniel Ford replies: In my opinion, Hap Arnold and George Marshall were highly political officers, while Claire Chennault was a down-and-dirty combat leader. We needed both sorts to win the war, but we ought not exaggerate the virtues of either.

My article was concerned with Hap Arnold as one of the individuals who brought British turbojet technology to the United States. His role in that coup has been much fabulized (for example, it has been said that he saw a test flight of the Gloster-Whittle jet plane, and that he handed over British blueprints to General Electric). I tried to reconstruct the story as it really happened, and I apologize if the result seemed to defame Arnold's reputation. Some readers of Flying Tigers *drew the same conclusion about my treatment of Chennault!*

Correction

The Mars Observer was launched on September 25, 1992 ("Beyond Earth," April/May 1993, page 1).

We welcome comments from readers. Letters, which may be edited, must be signed and include a daytime telephone number. Typed letters are preferred. Write to Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.* Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

Gemini Rising

MIKE GRAHAM

It was the mid-1960s all over again for a weekend last spring as 13 astronauts who orbited Earth during Project Gemini were inducted into the U.S. Astronaut Hall of Fame in Titusville, Florida. The induction ceremony, held on March 20, capped a two-day reunion for the sixty-something pioneers who in 1965 and 1966 tested the rendezvous, docking, and spacewalking techniques that were later used on the Apollo missions. The celebration included a parade that almost didn't happen.

The Saturday morning procession, in which the Gemini astronauts were to cruise through nearby Cocoa Beach in Corvette convertibles, was called off because of rain. Skies cleared minutes later, but it was too late—the men of Gemini had disappeared. "All the astronauts decided to go out and drink Bloody Marys and buy lottery tickets," says an amused Howard Benedict, executive director of the Mercury Seven Foundation, which operates the U.S. Astronaut Hall of Fame.

Helpers rounded up most of the honorees, "but we never did find Tom Stafford," Benedict says. Waving at the crowds from Stafford's Corvette was an unidentified stand-in wearing a spacesuit costume.

Some parade watchers thought they were looking at Gemini 8's Neil Armstrong, but he didn't join the celebration until moments before the astronauts were inducted and museum displays of their mementos were unveiled. Armstrong, who has shied away from public appearances since becoming the first human to walk on the moon, also missed a news conference at which his colleagues lamented the U.S. space program's political woes. According to Frank Borman, who commanded Gemini 7 and Apollo 8, today's difficulties arose from "a dichotomy in our society in the '60s. Those of us here today were involved in what was a great nationalistic effort to beat the Russians in the space program. Half the other people in the society were throwing rocks and bombs and dodging the draft. They're running the country now."

Throughout the festivities, the Gemini astronauts regaled fans and embarrassed one another with tales of their exploits. John Young, a two-time Gemini astronaut who holds the world's record with six spaceflights, boasted, "All the stuff I know would make *The Right Stuff* look like a Sunday School picnic."

—*Beth Dickey*

UPDATE

First Flight

Using the shuttle's robot arm, Ellen Ochoa ("The Class of 1990," April/May 1990) placed a solar research satellite in orbit and retrieved it 48 hours later during a *Discovery* flight last April. Ochoa's first flight lifted off two days late in a spectacular night launch that was visible for hundreds of miles.

The Beltway Breakfast Club

On a clear day you can fly to breakfast—that is, if you're breakfasting with Washington, D.C.'s airborne traffic reporters, observers, and their pilots who get together every few months to swap stories at field elevation instead of high above the District of Columbia's thoroughfares.

Walt Starling, a pilot and reporter for WLTT-FM, organized the breakfast club because "we need to look out for each other, since we're all flying above Washington each day at the same time—I mean that literally."

After they finish telling frazzled commuters how best to navigate the morning traffic, club members fly their Cessnas to Maryland's Montgomery County Airpark. Rob Fettus, who owns P.J.'s Landing, a small restaurant at the end of the runway, opens early just for the gathering, with pots of coffee and plates of pancakes, French toast, bacon, and sausage ready for the dozen or so guests.

It's not as easy for a bunch of pilots to fly to breakfast as one might think. Many members have other jobs to supplement

their traffic reporting, ranging from mortgage banking to running a bubble gum machine concession. Rich Bettinger, chief pilot for the Montgomery County transportation department's traffic division, has the complicated task of finding a date when everyone's calendar is clear and Fettus is available to open early. Along with clear calendars, he needs clear skies. "You don't drive to breakfast when you're a pilot," says Starling, "you fly."

The venue for the next get-together may change. Scott George, traffic pilot for WMZQ and WTOP, recently bought a house with a swimming pool, which occasioned discussion about a pool party and the chance to hone competitive swimming skills. "This year," someone said over the clatter of dishes being carried to the kitchen, "for sure we've got to beat that Philly traffic team in synchronized swimming."

—Ellen Crosby

UPDATE

Strung Out

A Delta rocket successfully deployed a 12.5-mile tether last March (Oldies & Oddities, June/July 1992). A spring-loaded 57-pound aluminum box jettisoned off the rocket unwound a polyethylene-fiber cord that was attached to a spool on the Delta's second stage. The first attempt to test a tether failed last year when a line jammed during deployment from the space shuttle *Atlantis*.

A Case of Identity

"He is the Napoleon of Crime, Watson," Sherlock Holmes told his faithful biographer. "He is the organizer of half that is evil and of nearly all that is undetected in this great city." Holmes was speaking of the infamous Professor James Moriarty, the criminal mastermind of Victorian London. But according to a NASA astronomer, Holmes may really have been referring to the era's most distinguished American astronomer.

In a paper presented to the American Astronomical Society meeting in Phoenix last January, Bradley Schaefer, an astronomer at the Goddard Space Flight Center in Greenbelt, Maryland, reported that the nefarious professor was probably based in part on Simon Newcomb, an astronomer and mathematician at the U.S. Naval Observatory who later became the director of the Nautical Almanac Office. Schaefer also believes that the inspiration for Moriarty henchman Colonel Sebastian Moran was British astronomer Colonel Arthur Drayson.

The 56 short stories and four longer tales that make up what enthusiasts call the "Canon" have provided an inexhaustible store of speculation for Sherlockians, who claim that Holmes and Watson really existed and that purported author Sir Arthur Conan Doyle was actually Watson's literary agent.

Schaefer, who has long been interested in Sherlock Holmes, originally wanted to try dating events in the Canon through celestial visibility, the study of the relationships of objects in the sky, which is often used by historians to date ancient events. But he learned that others had already tried that. When Schaefer mentioned to an editor at *Sky & Telescope* that he was still interested in doing something Sherlockian, "he said, 'Yeah, yeah, one of our editors said he knew who Moriarty was.' And that's when I got ahold of Ron Schorn."

COURTESY BRADLEY SCHAEFER

Ronald Schorn had postulated the Moriarty-Newcomb connection in 1978 but never published his theory. Like Moriarty, Schorn found, Newcomb was a brilliant mathematician and astronomer who had written a paper on the binomial theorem around the age of 20 and had published works on asteroids (Moriarty's *The Dynamics of an Asteroid*, said Holmes, was "a book which ascends to such rarefied heights of pure mathematics that it is said that there was no man in the scientific press capable of criticizing it"). Both men had once been professors at small universities. Furthermore, a contemporary of Newcomb's later wrote that the professor was a "dynamic and intimidating individual" who was "highly successful as a leader, in the sense that he got things done, but he was more feared than liked." There's little doubt that Holmes could have described Moriarty in similar terms.

"That's when I went out and started looking into the history of these guys for real," says Schaefer, "and found that, lo and behold, it was actually a pretty good match."

The only thing Schorn's theory lacked was a tangible link between Newcomb and Sir Arthur Conan Doyle. Schaefer found it in astronomer and mathematician Alfred Drayson. Doyle and Drayson had been close friends when both lived in Portsmouth—Doyle even dedicated a book to Drayson. Schaefer theorizes that Drayson, who often cited Newcomb's work in his own studies, told Doyle about the American astronomer, and that the author later used Drayson himself as the model for Colonel Sebastian Moran, Moriarty's right-hand man. Both Moran and Drayson had been colonels stationed in India. Both had written books about big-game hunting and had stalked wounded animals (Moran a tiger,

U.S. NAVAL OBSERVATORY

A NASA astronomer postulates that U.S. astronomer Simon Newcomb (left) was the model for Arthur Conan Doyle's Professor James Moriarty (below, left)…

…and that Colonel Sebastian Moran (above, being arrested as Sherlock Holmes watches) was modeled after British astronomer Colonel Alfred Drayson (left).

Drayson a leopard) down a drainage channel. Both made money at whist (though there is no evidence that Drayson, like Moran, cheated). And Doyle's description of Moran—a man with a "high, bald forehead" and "a huge grizzled moustache"—fits Drayson.

"For a while there," Schaefer says, "I was even toying with the idea, 'Gee, Drayson might have even been Moriarty,' for, after all, he was an astronomer-mathematician who was well known. But it rapidly became apparent that Newcomb was just infinitely better and Drayson fit Moran so well." Schaefer even traveled to England and discovered that Drayson was

working at the Greenwich Observatory when Newcomb visited there.

Last March Schaefer presented his findings to the Red Circle, a group of Washington, D.C. Sherlockians, and recreated the demonstration Professor Moriarty had made on eclipses to Scotland Yard's Inspector MacDonald. It was a tough crowd, one that knew that "it is a capital mistake to theorize before you have all the evidence," as Holmes told Watson. But perhaps the members of the Red Circle also recalled another Holmes maxim: "Circumstantial evidence is occasionally very convincing, as when you find a trout in the milk, to quote Thoreau's example."

—*Tom Huntington*

"It is more noble to convert aircraft into furniture than beer cans," says John Wood. A Concord, Massachusetts businessman and pilot, Wood combs salvage yards near Davis-Monthan Air Force Base in Tucson, Arizona, for old aircraft cockpits and designs functional furniture around them. The coffee table is an incarnation of a Convair T-29 instrument panel; the desk was originally the cockpit of a Grumman Albatross.

JOHN WOOD (3)

UPDATE

Fit to Fly?

A United Airlines weight policy, unenforced for 18 months while the airline and the flight attendants' union fought over it, was reactivated last March ("The Flight Attendants," April/May 1993). According to the policy, any flight attendant who is 11 pounds over his or her maximum allowable weight, which is determined by height and age, will be suspended for 10 days. The offender may lose weight, transfer to a different job, or quit.

The Not-Really-Red Planet

At this moment a spacecraft called the Mars Observer is speeding toward its destination, armed with a high-resolution camera and other sensors that will give us the most detailed views yet of the Red Planet. But that's not good enough for Carter Emmart, a California-based space artist (and *Air & Space/Smithsonian* contributor) with a hunger for realism. "We've come down to a culture of square eyeballs," he says, pointing out that planetary scientists spend much of their time peering at computer screens. Furthermore, he says, the public's images of Mars have been shaped by over-enhanced computer-processed images. "Nobody knows what Mars looks like anymore," he adds.

Emmart wants to change that. Last January, when Mars made a fairly close approach to Earth, Emmart and some of his colleagues gathered at Lick Observatory on California's Mount Hamilton to become true Mars observers. The artists had pleaded their case to *Sky & Telescope* magazine, which ponied up $1,000 to rent the 36-inch refracting telescope for four nights. Arriving at the telescope armed with Martian maps and paintbrushes, the artists got a warm but bemused welcome. According to the attending technician, anyone who uses the 36-incher must be approved by an oversight committee. He added, "I would say that you people are pushing the outside of the envelope."

Inside the dome, the venerable telescope stood waiting, with controls made from ship's wheels—"It looks like something out of Jules Verne," says Emmart—and the body of James Lick himself buried in its concrete foundation. When the huge instrument was pointed at Mars, some 58 million miles distant, the artists were amazed at what they saw. Recalls Joel Hagen, "For the first time I

SOUNDINGS

was looking directly at [Mars]—not a picture of it, but at *it.* I was seeing detail. It was a real place, a planet, not a dot of light in the sky."

Mars' dark markings, regions of dark rock and dust, stood out so clearly that "I didn't need a map," says Emmart. In fact, he saw far more than he could capture on his sketchpad—"tantalizing areas of low contrast, very hard to sketch but very beautiful." As for color, interpretations varied, but all agreed on one point: the Red Planet is misnamed. "It's bright yellow," says Beth Avary. Emmart saw a salmon-colored orb tinged with gold. The dark markings appeared greenish to Avary and Hagen, just as they once did to astronomers who thought they were areas of vegetation. Now, as then, Emmart cautions that such verdant hues could be an optical illusion.

The artists returned to their studios to capture on canvas what they had seen. Hagen says he took home an astronaut's-eye view of Mars. "I let myself believe I was in a spaceship approaching the planet," he says. "I realized this is pretty much what it would look like, looming as a destination. It felt that I was heading for a desolate, inhospitable outpost—beautiful, but lonely and cold. And a sense of an increasingly tenuous link to a warm home planet. I felt not so much excitement—how fascinating it would be to explore—but how good it would be to come home again."

—Andrew Chaikin

UPDATE

SST in Foster Care

The Boeing SST mockup that for years lorded over worshippers at a museum-turned-church in Kissimmee, Florida (Soundings, December 1990/January 1991), was saved from salvagers by a retired NASA engineer in Merritt Island. Charles Bell, who has been collecting aerospace hardware for 20 years, bought the Boeing 2707-300 for an undisclosed price and has stored the disassembled mockup on a fenced lot within viewing distance of Route 3, a few miles south of Kennedy Space Center's south gate. Bell has offered to help restore the mockup if a museum will take it off his hands.

Shock Therapy

Florida's Kennedy Space Center is one of the world's lightning hot spots. With bolts whipping from the sky an average of 80 days a year, rocketeering can be a risky proposition. NASA thought it had its bases covered with a system that was 99.5 percent lightning-proof, but it seems that infinitesimal leaks are threatening shuttle cargo. Engineers fear that tiny fingers of lightning—barely perceptible but potentially harmful to hardware—are tickling payloads stored in the payload change-out room on the shuttle's service tower.

Kennedy's anti-lightning system consists of a grounding cable, called a catenary wire. The cable is suspended from a lightning rod atop the service tower and anchored at opposite points 1,000 feet from the bases of the center's twin launch pads. The system dates back to the 1975 Apollo-Soyuz rendezvous. "We had to meet the Russians, and it was a very critical time," says Ron Bentti, chairman of the center's lightning safety committee. "We were launching in July, and that is the highest activity period for lightning."


NASA

Lightning strikes the shuttle Columbia *at launch complex 39-B.*

The lightning leak was discovered in 1988, when technicians were testing electrical systems on a military payload scheduled to be launched from *Atlantis*. During the test in the change-out room—the storage room that mates to the shuttle payload bay for cargo transfer—an electronic device "flip-flopped," and afterward, Bentti recalls, "we realized we were getting some lightning effects into the room, even though our catenary wire was functioning properly." NASA installed lightning sensors in the change-out room, but Bentti says they're not in the right spots to provide reliable data.

Last December, in the first test of the catenary wire system since its installation, engineers repeatedly zapped the shuttle launch pad with 10,000 amps—equal to a minor stroke of lightning. (The most powerful bolt the wire has ever recorded was 159,000 amps. The system's theoretical limit is 200,000.) The test measured lightning effects at locations inside and outside the change-out room to determine the best location for the sensors and to pinpoint weak spots in the room's shielding, such as cracks in the doors, rubber seals, and wire cables.

What to do about the problem is a cost question. The test ran about $100,000, and Bentti guesses it would take another $200,000 to properly insulate the change-out room against the sneaky advances of nature. "Lightning problems are very low on the priority list," he says. "That's one reason why it's taken all these years to actually do the test."

—*Beth Dickey*

Bringing Secrets to Light

Allan Janus has more artifacts than shelf space. An archivist with the National Air and Space Museum, Janus is coordinating a small exhibit that will showcase the Museum's rich stash of printed history. The tricky part is coming up with a selection that best represents all of the archives' treasures, which range from old diaries and corporate records to engineering drawings and training posters.

Normally, the objects in the archives are kept squirrelled away, either on the Museum's third floor or at the Garber facility in nearby Maryland. This keeps them safe, of course, but it also keeps them from being fully appreciated. "We all had papers, items, and we would often say, 'Jeez, this thing should go on display,' " says Janus of his fellow archivists. So last year, he and some colleagues began devising an exhibit that would give visitors a chance to experience the thrill archivists feel when chancing upon a particularly striking bit of history.

Opening this June, the mini-archive will be a different kind of exhibit for the Museum: instead of using historic objects to illustrate a theme or an era, such as wartime aviation or the moonflight program, it will give visitors the chance to savor a few choice aerospace artifacts simply for their own inherent beauty or quirkiness. Naturally, the archivists had their own favorite artifacts to nominate: Janus was particularly charmed by a mysterious 1910 photograph of a small grinning child posed at the controls of a vast biplane. Other Museum staffers made suggestions as well. Gregg Herken, chairman of the space history department, had been part of a team of Soviets and Americans who in 1989 witnessed the destruction of SS-20 ballistic missiles in Russia. He offered the archives exhibit a "class photo" of the team gazing into the camera while an SS-20 explodes in the distance.

Janus recalls that his boss, Thomas Soapes, had to keep reminding him to edit the selection of artifacts. "Every time I would find something I would say, 'Oh my God, we've got to show this, this is

A new exhibit displays bits and pieces of history: aircraft spotter playing cards, ca. 1942, and a baggage label (center) from an airline that operated between 1930 and 1934.

In this 1916 stereo view, British soldiers observe the impression made when a German zeppelin commander fell from his burning ship.

PHOTOGRAPHS BY MICHAEL RUZICKA

The archivists wear gloves when handling a vulnerable 1908 glass negative and prints of the first Wright military aircraft.

In the oldest known photograph of American aeronautics, John Steiner's balloon is inflated in Pennsylvania during the summer of 1857.

CENTER FOR EARTH AND PLANETARY STUDIES

With 100-foot resolution, Landsat 5's Thematic Mapper captured the smoke plumes (lower right) from power plants near the Krusne Hory forest in the Czech Republic. The satellite also captured the effect of this smoke, produced by burning low-grade, sulfur-rich coal taken from strip mines (rectangular shapes near the smoke plumes). The wide brown swath running diagonally through the image indicates dead or dying trees.

Soon to be displayed in the Museum's first-floor Looking at Earth gallery, the photograph is part of the database being assembled by the Museum's Center for Earth and Planetary Studies to document the loss of forests.

beautiful, or this proves something very interesting, or this lets people know that we have this whole class of thing here,' " says Janus.

But restraint was the order of the day: space for the exhibit was limited to a small room installed under one of the Museum's escalators. "Now, I had thought originally that something a lot more obvious would be nice so that more people would see it," says Janus, "but the area under the escalator is very nice because it's so dark." Sunlight would damage the objects to be included—all real artifacts, rather than mockups and photographic copies, as are sometimes used in other Museum displays. The display cases may include some "on demand" lighting—lights that visitors turn on themselves—so that the artifacts are subjected to as little light as possible. Those items that are especially vulnerable to light, such as a glass negative used to produce a photograph of a Wright military Flyer, will be rotated in and out of the exhibit. "That's one of the things we want to get across in the show," says Janus, "...that part of the function of archives is not just to let people see [an artifact] and help people research with it, but to preserve it."

Among the rarer items to be displayed are an 1857 photo showing a hot-air balloon being inflated and an 1814 treatise on bird flight mechanics and ornithopter designs. Says Janus: "Those seem to be fairly totemic objects—things we really had to put in," since they are firsts of their kind: the picture is the first known photograph showing some form of American aviation, and the treatise is perhaps the first book on flight published in the United States. Other items were included to give visitors an idea of the sweep of the archives' holdings: baggage labels from airlines long gone, business cards with flight-related illustrations, pilots' manuals from both world wars, and illustrated "airplane spotter" playing cards that teach aircraft identification. Perhaps the most shocking artifact is a World War I-era photograph of a group of British soldiers gathered around a spot on the ground that clearly bears the impression made by the body of a German who had fallen out of a shot-down zeppelin.

A World War I leaflet warned U.S. infantrymen not to fire on their own air support.

"I really wanted stuff that would suck people in," says Janus. The wide-ranging selection may do more than that. Some visitors will doubtless come away inspired to pursue their own archival passions—looking up photos of their old squadrons, for instance, or those of their parents. Whatever their interests, Janus and his fellow archivists are prepared: the little exhibit will include instructions on how visitors can find out about using the Museum's archives themselves.

—*Perry Turner*

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY: (202) 357-1729.

June 5 Monthly Sky Lecture on a topic of current interest in astronomy. Einstein Planetarium, 9:30 a.m.

June 9 Exploring Space Lecture: "The New SETI." Sallie Baliunas, deputy director of the Mount Wilson Institute and an astrophysicist at the Harvard-Smithsonian Center for Astrophysics, will explain the search for radio broadcasts from other worlds that could be evidence of extraterrestrial intelligence. Einstein Planetarium, 7:30 p.m.

July 3 Monthly Sky Lecture on a topic of current interest in astronomy. Einstein Planetarium, 9:30 a.m.

Extended Summer Hours Beginning Monday, June 14, and continuing through Monday, September 6, the National Air and Space Museum will open at 10 a.m. and close at 6:30 p.m.

Museum Visits For a free planning packet, write Smithsonian Information, Smithsonian Institution, Washington, DC 20560 or call (202) 357-2700. Daytime parking near the museums is limited.

TRAINING FLIGHT

Every page of the 1940 *Flight Jacket*, the naval aviation yearbook from Pensacola, Florida, has a pair of Navy wings. It is a seductive emblem. The Navy put it on every page so we wouldn't forget for a single moment why we were there. Going to flight school at Pensacola was the biggest thing that had ever happened to any of us. The place was tough but honest. One in three cadets would leave without the gold wings.

Roommates came and went. A new class arrived every two weeks, and in my room were guys from all over the country—Cricket Hill, Virginia; Lenni Hills, Pennsylvania; Flatonia, Texas. I was from Summerland, California. Flatonia didn't stay long and Lenni Hills was killed almost as soon as he graduated. Cricket Hill was in a PBY amphibian that somehow managed to land on top of a Greenland glacier in thick fog. Another roommate disappeared on a flight to Hawaii, and yet another was killed when the Japanese hit Cavite in the Philippines.

In the year and a half before Pearl Harbor I morbidly kept track of calamities by circling the photos of the dead in *Flight Jacket*. The first to be circled, alphabetically, was Paul Alter; the last, Marv Zimmerman. In between these two were an awful lot of black circles—guys who had spun in making night landings on carriers, flown into high-tension lines, hit each other in formation, or simply disappeared at sea. After Pearl Harbor I stopped keeping track.

My own records noted that I had pranged a number of airplanes—one took down a set of high-tension lines, two I ditched, and one I landed in downtown Jacksonville. One of my aircraft had caught fire, one had been hit in a midair collision, and several had been shot at. I had also flown over 80 missions, sunk some ships in low-level bombing, battled fighters, flown through typhoons, and seen so many airplanes crash, burn, explode, or collide in midair that I could no longer keep track of them. Eventually I seemed to be in a constant state of fear, in an airplane or out of it.

By the winter of 1943 I had logged some 2,000 hours, most of it in twin-engine land- and seaplanes. When the Navy got its version of the B-24 Liberator, the PB4Y-1, I began to train in it at Chincoteague Island in Virginia.

The Navy did a funny thing with the Liberator: they installed a non-pilot navigator. Every Navy pilot shot the sun and stars, used plotting boards, did dead reckoning, flew wind stars—and here came a navigator who would do nothing else. My crew was mildly disdainful of the arrangement. A long, dumb training flight—three legs, 1,800 miles, 10 hours, all over water—would be made just for his sake, accompanied by a navigation instructor.

Except for myself, as pilot, the crew was green. The six gunners and radio men averaged 19 years old. Buzz, the crew chief, was 21; the copilot, Todd, 22. Our training flights had the atmosphere of a bus en route to a high school football game. The tail gunner was convinced that he sang like Dick Haymes and occasionally tried to convince the rest of us by singing over the intercom. The bow turret gunner did splendid imitations of Donald and Daffy Duck. Joe, the non-pilot navigator, was a famous softball pitcher. Buzz and I, the least talented of the crew, fell back on the fact that Buzz had been based at a refueling station a hundred miles up the Essequibo River in British Guiana and I had flown there often in a patrol squadron. We began our stories with, "Well, down in B.G. one time, I remember this guy fell into the river"; then would come the piranha part. We were all stars of some sort, but none of us could compare with Todd the copilot.

Todd had gotten out of half the training flights in a medical *tour de force* that had included problems with his eyes and ears and various inner sanctums where symptoms were harder for the flight surgeon to judge. Todd talked about valvulae conniventes and the receptacle of the chyle and organic weakness in these areas and got away with it. The other ensigns disliked him because one of them constantly had to take his place and fly an extra hop.

The truth was that Todd was afraid to fly, or had become so after marrying his 17-year-old sweetheart. He couldn't bear to be away from her for even a few hours. When he did fly he brought along some talisman—a letter or picture or her charm bracelet. Todd could not take off or land a B-24, and what's more, since he got married, he said he never intended to learn how.

After this flight, we would be finished with the operational training program and would leave for a hotel at Old Point Comfort on the Chesapeake Bay for a few days before flying to England. We knew that if we didn't finish up, anything left undone, including perhaps this 10-hour flight, would have to be completed at the possible cost of time at Old Point Comfort.

The morning of the flight the aerology man told me there was a big cold front out to sea. It should be well north of our sector, he said, and it shouldn't be very violent if we did get into it. We took off at noon, flew a wind star, and set off on the course given us somewhat pompously by the navigation instructor, who was one of those guys who wore everything wrong. He wore his overseas cap, for instance, under his earphones, all puffed up like a tea cozy.

Buzz made his daily announcement about the fuel gauges, which were notoriously unreliable glass tube sight gauges. According to them, we had fuel for 12 hours at normal consumption, and Buzz planned to compute consumption by taking fuel flow meter readings every hour. I put the airplane on autopilot and we began the eating, coffee drinking, and smoking that would go on all afternoon. After a while Todd pulled out a letter, unfolded it tenderly, and began to read. At the nav table Joe was busy under the instructor's eye. A little after four we finished the outbound leg and turned north. The instructor pointed out that Joe was doing compass deviation, drift, and magnetic variation corrections. (A month


PIERRE MION

later Joe took us over the middle of Spain by cranking in the magnetic variation backwards.)

Far to the north we began to see huge masses of cumulus clouds. The radio man decoded a message that said two other airplanes from our base had canceled their flights in sectors to our north and had reported a big cold front with cloud tops at 30,000 feet. If we had not had an instructor on board I would have faked it, cruising around not too far from land and sending phony position reports until our estimated time of arrival came up.

We went on, bending our track to the west to distance ourselves from the largest clouds to the east. But late in the afternoon we came right up on the face of the front. It was indeed a big one. The clouds were solid and boiling and reached way up, far higher than we could climb. Below them was the typical ugly roll cloud—black, full of rain, and sagging almost to the sea. Over our earphones came the crackle of electricity.

No matter—we would pick our way back and re-plot a course to the base. But it was soon obvious that neither Joe nor the instructor was able to plot the course changes fast enough. They kept poking their heads in the cockpit to ask for the heading we had been on a couple of minutes earlier.

I looked up at the big cauliflowers and knew we would have to fly through them. I told the crew to ready themselves and told the navigators to watch the course changes, time them, and just do the best they could. I snapped off the autopilot and headed into the roll cloud at 800 feet.

We began to bounce—hard. Lightning flashed ahead and then starboard. A gust of rain hit the skin, then violent hail. The roll cloud swallowed us. I looked over at Todd. He was staring ahead, letter in hand. "A real washer biter," I yelled, which meant your behind was biting the washers out of the seat.

The altimeter said 600 feet when we broke out about 80 feet above the water. Spume flew downwind in streams like fire hose torrents and the wingtips seemed to be lower than the huge waves rolling under us. I reset the altimeter. A few minutes later it said we were 200 feet *under* water (barometric pressure changes radically in cold fronts).

We were back in clouds. Now came a steady barrage of hail. We started climbing at 2,000 feet per minute, the airframe creaking and snapping. I pulled back the power, lowered the landing gear, and added 20 degrees of flaps in an effort to slow our ascent. We went up even faster.

I pounded on the pedestal to get Todd to help me wrestle the yoke. At that moment Buzz appeared between the seats. "Get him out of there and come help me," I shouted.

We went on up, pressed into our seats, in the midst of a fearful racket of surging propellers, thrashing hail, electrical discharges, and vague cries and yells from aft. The wings were whipping like balsa. At 19,000 feet, according to the unreliable altimeter, we stopped climbing. We had a second or two of calm, then

started down. Instead of being pinned in our seats we were drawn upward against the seat harnesses. All kinds of things were plastered against the ceiling, including the new cordovan shoes I had taken off to keep from scuffing them on the rudder pedals. Coffee cups, pencils, maps, and cigarette butts clung up there as if drawn to a magnet. We had by now retracted the gear and flaps and applied full power, and still we dove.

We broke out of the clouds at 1,000 feet and went skidding across the waves in a tremendous yaw. The wind had swung around 60 degrees. We seemed to be heading south and drifting to port. I forced the airplane around into what might be a westerly heading, but I really couldn't tell. I could no longer think.

I looked into the nav compartment. The instructor was on the floor, braced under the nav table. His puffy hat was on sideways, sort of a Napoleon look. I called the radio man on the intercom, but he talked so fast I couldn't follow him. I waved for him to come up.

"Get a bearing from the base," I shouted.

"Like I was telling you, I can't get the base no more."

"Why the hell not?"

His head swayed back and forth near my ear. "I dunno. Just the conditions, I guess."

We staggered on. The airplane was light now and even climbed a little under reduced power. It was now 10 p.m. The allotted time for the flight had elapsed, and I hadn't a clue where we were—over land, over water, north or south of the base, east or west of the Allegheny mountains.

In my earphones I heard someone say faintly, "Negative, not able any approach." Whoever he was talking to on the ground demurred. A moment later the voice said angrily, "The hell with that! We're leaving the ship."

No one answered my calls on the same channel. I thought about all of us jumping out. Perhaps we were a hundred miles out to sea. On the other hand, perhaps we were about to run into a mountain.

Buzz told me that the fuel levels in the sight gauges had disappeared. I knew he didn't trust them even when he could see them. "What do you figure?" I asked.

He shrugged in the dim light. "We got maybe an hour set up like this. If you need power to climb or something, then I don't know."

It was midnight. We had to be over land. I didn't bother to reason why, I just decided we had to be. I announced on the intercom that we were going to climb and then jump out in exactly 10 minutes.

Buzz had opened the bomb bay doors. Their strong lights shone down on scudding mist and rain. The people in the nav compartment started aft and disappeared in the catwalk. But the nose didn't come down as it would have if people were exiting from the rear.

Buzz and I got up. Just ahead of me as I started to squeeze through the nav compartment, he grabbed my arm and pointed down the catwalk. Way aft we saw legs—lots of them. No one had jumped.

I looked down through the bomb bay

I WASN'T GOING TO JUMP EITHER. NOT INTO THAT DARK VOID, NOT WHILE ALL FOUR ENGINES WERE RUNNING.

doors. I wasn't going to jump either. Not yet, not into that dark void, not while all four engines were running. We sat down again.

"Okay, you won't do it," I croaked over an intercom. "We'll just let down until we see something—or hit something."

One thousand feet. How far off could the altimeter be? Now 500. We broke out almost lined up with a long row of lights. An airfield! No, the lights were on the masts of fishing boats moored in a line. Dead ahead, a hazy glow spread through the clouds. We ducked in and out of the low ceiling, which was maybe 300 feet.

Almost crying with excitement I cranked the handle of the automatic direction finder. Suddenly the needle twittered and began to swing through an arc of about 20 degrees. As we followed its uncertain waving I could hear the beginning of a signal. In minutes I knew it was the Washington, D.C. low-frequency range. Lights, again in a long row! It must be Washington National Airport!

I let down, lined up with the lights, and lowered some flaps. I had my hand on the landing gear lever when Buzz yelled, "The arsenal! Aberdeen Proving Ground!" We flew down the long street of ammo bunkers. The needle, steadier now, still pointed dead ahead.

Fifteen minutes later, there it was, off to the left, just a glimpse of an airport. The runways were lit by red lights, and there was a big red X in the middle that began to disappear off the left wing. I banked the airplane to port, worrying about stalling at our low speed, but damned if I was going to lose that red X. Down came the gear and some flaps. At that moment a huge white shaft flashed by on the right, very close. I had just missed hitting the Washington Monument.

The airport looked like it was under water. At the last moment Todd poked his head in and shouted, "You dumb bastard, you're landing in the river!"

It certainly looked like it. When we hit, a thick sheet of spray flew over us. We bobbled along, went off the runway, and skidded to a stop on the grass. I grabbed my new cordovans for some reason and piled out with the others, who were rolling in the water, crying and laughing and hugging each other. Some of them grabbed me, kissing me and pounding my back. They either didn't know or didn't care that I had nearly killed them all.

A jeep with masked headlights arrived and a man with a white brassard on his arm shone his flashlight on us. "Didn't they tell you?" he shouted. "The field is closed. You can't land here. Who is in command of this airplane?" Prone in the grass I held up one arm. The man pointed at the huge red X. "See that?"

"It was an emergency," I said. "We were lost. Out of gas."

"You're under arrest until we see the duty officer," he said.

There were hoots and howls of derision. "Shoot us! Kill us! Tell the duty officer he can insert this B-24 sideways, and by the numbers!"

It was 2:45 a.m. We had been flying for 15 hours. The duty officer said we had been reported missing two hours ago. Two inches of rain had fallen in one hour. We spent the rest of the night in big lounge chairs in the airport waiting room.

Back at Chincoteague the Navy convened the usual board, this one to see why a training flight had been sent out when the biggest cold front of the year was hanging off the coast. They didn't go into the confusion and mistakes that had characterized my performance but blamed the people in charge of training. Todd turned in his wings.

Also at the hearing was a captain who came down to inquire into another matter. An aircraft, presumably military and almost certainly ours, had flown twice over the White House between 2 a.m. and 2:30 at "a dangerously low altitude." The occupants of the White House had been terrified.

I wrote to Franklin D. from North Africa, explaining what had happened and apologizing for scaring him. Perhaps he and Eleanor had been frightened, I wrote, but believe me, Mr. President, no one was more frightened that night than the crew in the airplane that went over your house. I never got an answer.

—Gordon Forbes

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Russia's Golden Ring August 20-31.

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NEW **Mongolia and China** August 29-September 20.

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Hungary September 13-27.

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Zimbabwe-Botswana September 16-October 3.

Himalayan Kingdoms September 16-October 5: Nepal, Bhutan, Ladakh.

Danube Cruise September 26-October 8.

Spanish Legacies October 8-23.

NEW **Walks in England's West Country** October 10-21.

Israel October 12-24.

Japan Journey October 15-27.

Pacific War 1943-44 October 16-November 1.

Imperial India October 16-November 11.

Russia and Estonia October 21-30.

Mexico Folk Art October 27-November 8.

Red Sea Cruise October 27-November 14.

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New Zealand November 27-December 11.

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NEW **Orioles Baseball** July 29-August 1.

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Grand Canyon Rafting August 20-29.

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Native Cultures of the Southwest August 22-September 1.

NEW **Yellowstone Hiking** September 1-11.

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Exploring Washington State September 5-12.

Smithsonian Treasures (Washington, D.C.) September 8-12: For Contributing Members.

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SEMINARS

Life on the Mississippi (Minnesota) August 4-10.

Hawaiian Botany/Volcanology (Hilo, Hawaii) August 8-12.

Mackinac Island Heritage (Michigan) August 23-26.

Carrier Warfare (San Diego) September 1-4.

Telluride Film Festival (Colorado) September 2-6.

Rare Books (Washington, D.C.) September 7-10.

RESEARCH EXPEDITIONS

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Washington, D.C. July 18-31: Archive documents at the National Air and Space Museum.

Costa Rica July 24-August 5: Monitor an active volcano.

Crow Agency, Montana August 18-24: Document the Crow Fair and Family Reunion.

RANDOM SIGHTINGS

From "The Oxcart Story," a recently declassified CIA paper detailing the agency's development of the A-12 Oxcart, a stealthy reconnaissance craft ("the President" is Lyndon B. Johnson; he made his announcement on February 24, 1964):

The President also said that "the A-11 aircraft now at Edwards Air Force Base are undergoing extensive tests to determine their capabilities as long-range interceptors." It was true that the Air Force in October 1960 had contracted for three interceptor versions of the A-12, and they were by this time available. But at the moment when the President spoke, there were no A-11's at Edwards and there never had been. Project officials had known that the public announcement was about to be made, but they had not been told exactly when. Caught by surprise, they hastily flew two Air Force YF-12A's to Edwards to support the President's statement. So rushed was this operation, so speedily were the aircraft put into hangars upon arrival, that heat from them activated the hangar sprinkler system, dousing the reception team which awaited them.

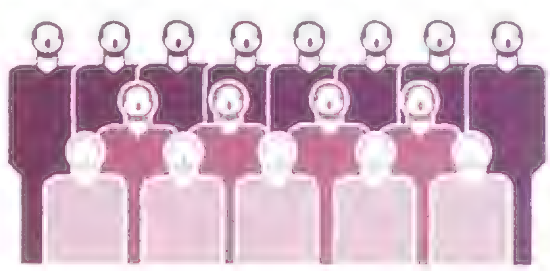
From an October 5, 1970 memo in the FBI's file on Wernher von Braun ("the Director" is J. Edgar Hoover; "Mr. Tolson" is Clyde Tolson, Hoover's right-hand man):

In 1970 it was decided not to invite Von Braun to speak at FBI Communion Breakfast. In this regard Mr. Tolson commented "He is a phony," and the Director concurred. Despite this weakness in his character, our investigations have not indicated any disloyalty to U.S.

From the August 18, 1992 issue of the tabloid Weekly World News:

A secret NASA satellite has recorded the voices of angels singing in space. Even eerier, the heavenly chorus is coming from the center of a massive black hole in the M-51 galaxy—20 million light-years away!

...Classified memos smuggled from NASA headquarters in Washington, D.C., failed to address the implications of the recording. But sources privately concede that it not only proves that angels exist, it confirms that heaven is a real place.



"The recording is precisely seven minutes long and the sound is so clear that it cannot be denied" [said a highly placed agency insider]. "You can hear thousands and maybe even millions of voices singing, '*Glory, glory, glory to the Lord on high*,' over and over again."

...NASA spokesmen [said] that the discovery of the black hole in the M-51 galaxy "was a stunning achievement and should not be minimized by rumors of the even greater discovery of angels in space."

From the October 24, 1991 Chicago Tribune, *as reported in the syndicated column "News of the Weird":*

Car thieves in Changwa, Taiwan, recently have been using homing pigeons for assistance. They steal a car, leave a ransom note and a pigeon, and then wait from their hideout for the pigeon to arrive bearing the ransom money. Police so far have been unable to follow the pigeons.

From the First Quarter 1992 issue of The 170 News; *the correspondent is Ryan "Brownie" Seals:*

On 29 June 91 I had a heart attack while taking off in my Pitts. The crash impact restarted the heart and I survived the crash. After replacement of my carotid artery and bypass of 5 heart arteries plus a rework of the prostate (6 weeks in the hospital) I am back up and about as good as ever. I am currently out of an airplane and a medical [certification] but am in the process of replacing both if banks and FAA will cooperate. Best regards to all 170ers.

From the January 1993 issue of Flight Safety Digest:

The MD-80 with 77 passengers on board was preparing to depart from a European airport when the controls jammed.

Mechanics summoned to the aircraft found three bags of bottled whiskey and vodka hidden under a hatch. It was determined that the bottles were smuggled aboard by the pilot, who was subsequently grounded for 10 months. The bags had prevented the controls from moving freely. The flight was canceled and the passengers were transported to their destination by other operators.

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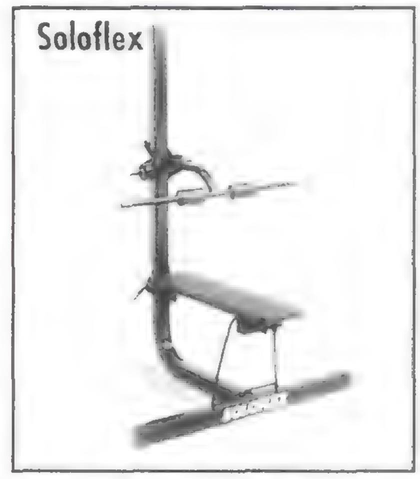

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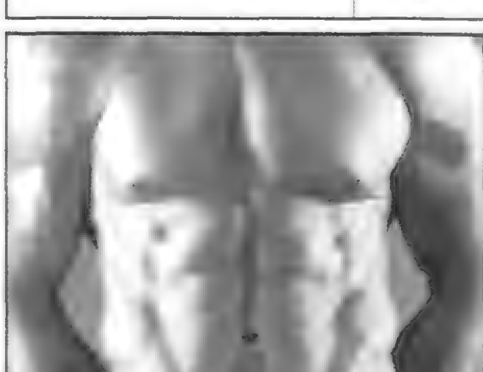

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by Elaine de Man

JORDAN COONRAD

FAST TRACK

Test flying is not just a job—it's a career path.

Captain Mike Bloomfield was driving down Sharon Drive, trying to figure out which of the identical beige stucco houses he'd be moving his family into, when he was suddenly overcome with a sense of dread. He flashed to a scene in *The Right Stuff* in which the tall, grim pastor, friend of widows and orphans, drives slowly down a street just like Sharon Drive, looking for a house just like the one Bloomfield was looking for, to console the young wife—now widow—of a test pilot.

Uh-oh, thought Bloomfield, a new student at the Air Force Test Pilot School at Edwards Air Force Base in California. *What am I doing here?*

"Back in the early days of flight test, the early '50s and all the way back to the Wright brothers, the only method

you had of evaluating a new airplane was to put a pilot in it and let him go up and see what happened," says Colonel Guy Gardner, commandant of the test pilot school. When the unexpected occurred—more often the norm rather than the exception—far too many pilots, despite valiant efforts, lost increasingly expensive "assets," military lingo for aircraft, as well as their lives.

Eventually, computers, simulators, and wind tunnels began to predict the outcome of a flight before a pilot even approached the cockpit. Once the aircraft was airborne, its sensory equipment sent flight data to engineers for real-time analysis. By the late 1970s, test piloting was a career with a real future. "Now when you strap on an airplane, you're pretty sure it's going to work," says Gardner. And that suits Mike Bloomfield just fine. The 34-year-old Air Force career man wasn't looking for a job burning holes in the sky. He wanted a job that would allow him time to spend with his family.

The fast-driving, hard-drinking, high-flying test pilots glorified in Tom Wolfe's book *The Right Stuff* have been replaced by a new generation, one with a more conservative attitude, due in part to refinements that computers and simulators have made to the test pilot's daily grind. Consider Gardner, an astronaut for 11 years before he returned to the test pilot school in 1991 as commandant and who is now with NASA's spaceflight administration. Twice he has sat on top of 1.6 million pounds of liquid hydrogen and oxygen waiting for the

The X-15 (replica), F/A-18 Systems Research Aircraft, SR-71, X-31, and X-29 (below, from left) were all before Air Force captain Pam Melroy's time (opposite), but she gets a kick out of test-flying the A-7 Corsair II. "You can learn so much from the older planes," she says. "You see where mistakes were made."

CHAD SLATTERY

Despite the high-pressure atmosphere of test pilot training, Chief Warrant Officer Ed Delehant and Lieutenant Colonel Robert Price, ex-director of the Navy's test pilot school, make time for a run every day, while Air Force test pilot student Mike Bloomfield keeps in the swing of things with his family.

JORDAN COONRAD (3)

shuttle's fuse to be lit. But when asked about the highlight of his career, he says, "You mean after the birth of my kids?" When Gardner retires, he'd like to be a high school math teacher.

A NASA engineer who requested anonymity started working at Edwards at the end of the X-plane's golden era and remembers the first advice she got. "Whatever you do," her supervisor said, "don't get in an elevator alone with any of the test pilots."

"Now they're all so *boring*," she says. "They all drive station wagons with bumper stickers that say 'Proud Parent of an Honor Roll Student.' "

In the technically sophisticated environment that characterizes today's test flying, boring can be a plus. "The kind of pilot we get coming to the school here is the type A-plus-plus, overachieving cream of the crop," says Lieutenant Colonel Robert Price, recently retired director of the Navy's Test Pilot School at Naval Air Station Patuxent River in Maryland. "But as they progress through the school they realize that test flying isn't going out and setting your hair on fire going as fast as you can. It's a very methodical, precise type of flying that is often, in a sense, quite boring. You have to hit that data point and hold it as long as you can. We teach them to plan the flight and fly the plan. Period. Don't go freelancing."

Nothing can kill a career faster. Lee Khinoo, who's been an instructor at Pax River for 12 years, remembers a helicopter pilot who wanted to apply but had a blemish on his record: he'd flown a helicopter under a bridge in Washington, D.C. "I flat told him, 'Do not apply,' " says Khinoo. "We need aggressive people. But we don't need stupid people."

Yet Price admits, "I think all of us who fly airplanes in this business have that hidden in our personality somewhere. But we try to keep it under control until we get off work and jump in our Corvettes."

To apply to the test pilot school at Edwards, candidates must have acquired a minimum of 1,000 flight hours (most have 1,500 to 2,000) and have earned a bachelor's degree in engineering or another technical field (most have at least a master's). Of the 160 or so highly qualified pilots, engineers, and navigators who apply for the two 11-month classes each year, only about 30 are chosen.

Once enrolled, students may fly as many as 30 types of aircraft, from a blimp to an SR-71. "This is probably the only place in the world where, no kidding, you can go up one week and fly the F-15, the F-16, go up in a glider, and fly a T-38," says Bloomfield. "It won't even happen after we graduate." Yet this is not the top of the pyramid for many of today's young pilots. A few, like Captain Scott Horowitz, set their sights on the astronaut program some 25 years ago, and the test pilot stint is just another stage to orbit.

Horowitz, now 36, was 12 when he decided that astronauts had the best job in the world. His sixth grade teach-

CHAD SLATTERY

Milt Thompson, who made14 flights in the X-15 at Edwards, recalls that 30 years ago "we could pretty much do what we wanted here. Now you're on radar control all the time."

er encouraged him with a letter that Horowitz still carries with him. "With your will and determination," it says, "you may become one of the astronauts of tomorrow." As a high schooler, Horowitz hung around Air Force and Navy bases, learning what credentials he'd need, and thus armed, he became a chronic overachiever. He finished high school in three years and graduated from college in another three. Knowing he'd need a master's degree, he went further and got a Ph.D. in aerospace engineering. When he was commissioned as an Air Force officer in 1982 the recruiter advised that Horowitz didn't want to be a pilot, he wanted to be an engineer. "No, no, no, you don't understand," Horowitz replied. "I want to be a pilot. Trust me on this one." The Air Force put his commission on hold, until a pilot slot opened up. Three months later, Horowitz gave up his $35,000-a-year engineering job at Lockheed in Georgia, postponed his wedding, and headed for officer training school in San Antonio.

Now he had a dilemma. He knew he'd need operational experience in fighters to get into test pilot school, but he also needed a thousand flight hours, and at age 26, time was running out. Horowitz volunteered to be an instructor pilot, and after three years in training command ("the only command where the enemy is in the cockpit with you," he says) he had racked up 1,300 hours. He then spent two years in Germany flying F-15s and entered test pilot school at Edwards in 1989. He'd been there 18 months when he got The Call from Don Puddy, NASA's director of flight crew operations. Puddy told him he'd been selected to be an astronaut. Then he asked if Horowitz was still interested.

Despite the glamour of making it to the top, the space program exacts a toll that some test pilots are glad they didn't pay—pilots like 67-year-old Milt Thompson, chief engineer at NASA's Dryden Flight Research Facility at Edwards, and Bill Dana, 62, assistant chief of flight operations. "Sure, there have been times when I wished I was in the space program," says Dana, who first came to Edwards in 1958. "Those guys have had some spectacular moments, and I'd give a million dollars to look back at the planet from the moon. But those guys paid a terrible price for that." While the astronauts spent years training for a single shot into space, Dana continued to fly at Edwards. "I got to do some things they didn't," he says, referring in particular to his 16 flights as project pilot for the X-15, the King Kong of rocket-powered vehicles and the aircraft he flew at 307,000 feet and at 3,897 mph. Thompson also flew the X-15, though not as fast and not as high. "Well," he says with a mischievous grin, "I didn't overshoot."

Dana was supposed to go only to 270,000 feet, but he missed his mark by 40,000 due to a faulty precision attitude indicator. "I could have salvaged it if I'd been really clever," he says, "but that was a pretty wild environment to be clever in. During acceleration the X-15 would start popping and banging and crackling like a hot stove while smoke poured into the cockpit." When Dana reached up to shut off the engine, he hit his preflight checklist with his elbow and popped open the clip, releasing a few dozen pieces of paper that flew around the cockpit. But what a view! From the right window he could see San Luis Obispo, and through the forward window, the Gulf of California. It was, quite literally, the high point of his career.

Thompson came to Edwards in 1956, two years before Dana arrived. By then Pancho Barnes' Happy Bottom Riding Club, a hang-out immortalized in *The Right Stuff,* had burned down and the Air Force was cleaning out its hangars, getting rid of experimental airplanes like the X-1, X-3, and X-4. Even though Edwards was still averaging five fatalities a year, young Milt Thompson thought, *Oh, Christ, I've missed it all.* Recalling those days now, he chuckles; in retro-

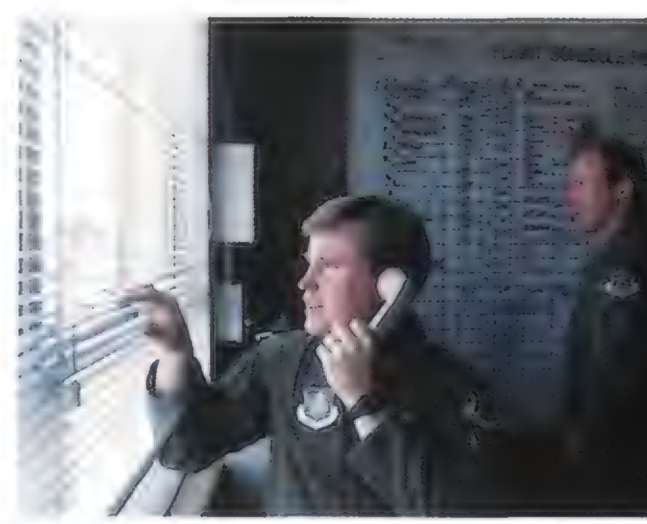
spect, he didn't miss much at all. In addition to his X-15 jaunts, he was the first person to fly the M2 lifting bodies, the wingless precursors to the space shuttle (see "The Legacy of the Lifting Body," April/May 1991).

Today's test pilots can only dream about flights like those. There aren't many firsts anymore. Nor does this generation have as much freedom as Thompson, Dana, and their contemporaries had, particularly in the early days of the X-15 program. "We could pretty much

JORDAN COONRAD (4)

According to one student, "Today's mission is no longer To Fly and Fight, but To Fly and Write" (right). Bill Dana (below) occasionally wished he had jumped into the space race but says he wouldn't have traded his flights in the X-15 and the HL-10 lifting body for any launch.

CHAD SLATTERY



The new generation of test pilots are considerably more subdued than their predecessors. Air Force captain Bob Nolan (above, right) says today's complex airplanes dictate an early-to-bed, early-to-rise lifestyle.

do what we wanted here," Thompson says. "There were no real restrictions, nobody monitoring where you went. Now you're on radar control all the time. It takes a lot of the joy out of it."

Every day after work the Edwards gang would congregate at Juanita's, a bar in nearby Rosamond, and discuss what sort of flying they were going to do the next day. "If I'd known I was going to live this long," Dana says with a grin, "I'd have taken better care of myself. But in those days you didn't think you were going to make it all the way. The loss rates were high and we all lived accordingly. So you didn't worry about things like physical fitness. But I think that a lot of the young pilots have figured out that exercise is a much better emotional release than alcohol."

"I got exercise," Thompson jokes. "Pushing open screen doors."

The X-15 marked the end of another era as well: computers had begun to do more in the cockpit. Today, the experience of test flying is more cerebral than physical. "It was tough for us old farts to give up the mechanical systems and fly by wire," says Thompson. "Soon, pilots will be little more than decision makers."

That may already be the case. Captain Bob Nolan, a 31-year-old student at the test pilot school, sums up the transformation. "The change in complexity and performance of airplanes drives you to go home, eat a good din-

In an era with few firsts, Navy commander Dave Venlet got the plum assignment of making the first carrier landing with the new T-45 trainer. Now that women can fly in combat, Lieutenant Susan Still (bottom) says: "I'll be able to take what I've learned in test flying and bring it to the fleet."

ner, and get a good night's sleep before you come into work," he says. According to one student test pilot, today's mission is no longer To Fly and Fight, but rather To Fly and Write.

Nonetheless, for Captain Pam Melroy, U. S. Air Force test pilot, class of June 1992, test flying exceeds her wildest dreams. "In the operational world you have very strict limits on what you're allowed to do with the airplane," she says. "Spins are something they teach you in pilot training, then for the rest of your career you try to avoid them. But here," she says, rolling her eyes, "the flying is fantastic. Unbelievable."

Melroy was flying refueling missions over Iraq during the Gulf war when she learned she'd been accepted at Edwards. Though she'd been in the Air Force seven years, most of her flight time—some 2,700 hours—was spent piloting a KC-10 heavy tanker. During her year at test pilot school she not only flew fighters, she made her first flight in an A-7D Corsair II, solo, with no simulator time and just one hour in the cockpit. On her second flight, she examined the A-7's "departure" characteristics—what happens after it stalls and begins an out-of-control descent.

Melroy replays that particular flight in a chair in a conference room at the school. "So you go out and you climb up to about 35,000 feet," she explains, "then you just honk on the stick and away you go! You're off on this wild ride." She clutches the arms of the chair with manicured fingernails and describes how the A-7 tumbled through the sky. Her head rolls around as it did in the cockpit until, at about 20,000 feet, the airplane began to regain stability. "And then," she says, "you climb back up to 35,000 feet and do it all over again! It's just great."

The test pilot experience crystallized for Melroy as she methodically recorded data for the duration of the plunge. "It's like I stepped over a line at that point," she says. "I realized I can do this. This is not that scary.

"You can learn so much from the older planes," she adds. "You see where mistakes were made and what a bad airplane feels like. That's what we're paid to do—to complain about the airplanes."

Lieutenant Lori Tanner, a test pilot instructor, had her share of ups and downs before she got into the Navy's test pilot school. Tanner was a 23-year-old with two mechanical engineering degrees who had twice rebuilt the engine in her 1968 Pontiac Firebird by the time she was 16. She told a Marine recruiting officer she wanted to fly fighters. "When he got done laughing," she recalls, "he told me to join the Navy." Before enrolling in test pilot school in 1990, Tanner flew A-7s in a electronic warfare "aggressor" unit against pilots training for combat. After test pilot school, she flew the T-45A, a highly modified British Aerospace Hawk that will be the Navy's next trainer.

The T-45 exemplifies the latest trend in aircraft acquisition. Brand-new airplanes aren't cranked off an assembly line anymore; today, as the aerospace industry slows to a crawl, the military modifies and upgrades existing aircraft. The Hawk needed leading-edge slats, modified brakes, nosewheel steering, and a new engine fuel control to bring it up to Navy standards. But every modification created a new set of problems, and every solution had to be tested. And someone had to make the first landing on a real carrier.

That plum fell to 38-year-old Commander Dave Venlet. "That was probably one of the highlights of my Navy career," he says. "It's as close as a Navy guy will ever get to a first flight because first flights are pretty much done by contractor pilots. But only Navy people get to do first landings on ships, and they come along very rarely."

Students may be flying the T-45 late this year, but Tanner isn't sure she'll

JORDAN COONRAD (3)

Student test pilots at Edwards Air Force Base hone their hand-eye coordination outside the cockpit (above). Captain Scott Horowitz (above, right) sharpened his skills by building his own airplane and last year achieved his childhood goal: astronaut trainee. En route to a shuttle seat, Navy test pilots may fly a TA-4 Skyhawk (right), A-7 Corsair II, T-38 Talon, and F/A-18 Hornet.

have the opportunity to join them at sea when they've finished their training. She has nine years of Navy service, and even when the Department of Defense begins integrating women into combat units, she will probably have too much rank and not enough carrier experience to go to sea as a lieutenant commander. She's made only 12 carrier landings; the men who would be working under her could have as many as 300. Nonetheless, Tanner says the rewards are staggering. "If I count the cost of jet fuel," she says, "I figure I'm probably making millions of dollars."

Timing may work out better for Lieutenant Susan Still, a 31-year-old Navy pilot who will graduate from the test pilot school in June. "I'll be able to take what I've learned in test flying and bring it to the fleet," she says. Still, who drives the newest Corvette in the Pax River parking lot, was an engineer at Lockheed for three years before she was commissioned as a Navy pilot in 1985. "It was hard to get here lacking that operational fleet experience," she says, "but now that I'm here, I'll be a graduate of the test pilot school just like everyone else."

Test pilot school is a carefully considered move on the military chessboard. "Becoming a test pilot is not a smart career move if you want to become a general," says Air Force major Dana Purifoy. "You go away to do test pilot training exactly at that point in your career when you need to get operational experience to shoot up in rank." But Purifoy, who was director of the

Joint Test Force for the Advanced Fighter Technology Integration F-16 until he moved on to the U-2 program, has no regrets. After all, who'd want to give up playing chicken with an F-16 and a mountain to be a general?

The F-16 Purifoy flew is a one-of-a-kind version designed to test advanced flight control technology and integrate cockpit displays like the All-Terrain Ground Collision Avoidance System, which will prevent "controlled flight into terrain," a stock phrase that appears on accident reports and refers to the primary cause of military aircraft crashes. It means that for whatever reason, the pilot has flown a perfectly good airplane into the ground.

"See that rock?" Purifoy points to the flickering image of a mountain on a video filmed from his airplane. The mountain is drawing closer, looming larger. "I know that rock very well." The pilot's job is to fly the AFTI F-16 at that particular mountain at 1,000 feet per second—680 mph—while the system predicts if he's going to hit it and, if so, determines when it should take over the controls and fly him out of harm's way. Purifoy describes the procedure as casually as he might describe delivering pizza, but he admits, "there's a little more pucker factor as we get closer to the ground."

Purifoy was involved in the development of the testing procedures and was responsible for safety planning as well. "You don't go into the airplane thinking something's going to happen that day," he says. "You go in confident nothing will happen because you've done the right kind of planning." Even so, he's quick to point out that the older generation of test pilots isn't the only one familiar with the danger zone. "The ground is as unforgiving now as it was forty years ago," he says, "and if anything we're going faster and lower and doing things in the middle of the night."

In the end, the only thing that today's test pilots might share with their predecessors is a profound desire to merge their passion for flying with a precise understanding of the aircraft. Mike Bloomfield is too busy to miss the eras of the Happy Bottom Riding Club or Juanita's. He's at school by 6 a.m., studying until classes start, and home by 5:30 so he can give the kids baths or sit on the swing with his daughter Courtney while she tells him about her day. "It's so easy to get all wrapped up in the work," he says. "But a hundred years from now, will it matter if I graduated from test pilot school? Probably not. But it will matter how my kids were brought up, because they're going to have an impact on the future."

Dave Venlet is considering what he might do next. "Every time I come to a three-year term I find something that looks fun and go do that," he says. "And here I am 16 years later, still having fun. And when I get to 20, if I'm still having fun, I'll stay. After the Navy, who knows? I may just become a barber. That appeals to me some days."

Lieutenant Lori Tanner told a Marine recruiting officer she wanted to fly fighters. "When he got done laughing," she says, "he told me to join the Navy." Tanner is now an instructor at the Navy's test pilot school.

MEDFORD TAYLOR

LITTLE LAUNCHES

Small spacecraft are becoming the wave of the present.

by Tony Reichhardt

Illustrations by Hal Mayforth

Tom Krimigis still remembers a time, back in the early days of planetary exploration, when the spacecraft were small, the opportunities were big, and the whole solar system lay stretched out ahead, a vast unanswered question. Krimigis had come to the University of Iowa in 1961 to study under James Van Allen, the space physicist who had sent the world's first science instrument into orbit three years earlier. One day Van Allen called Krimigis into his office and asked him, a mere second-year graduate student, if he'd like to be part of the science team on Mariner 4, NASA's first successful mission to Mars.

"That's the way the agency was doing business in those days," recalls Krimigis. "It was an amazing atmosphere. You practically had your pick of which pioneering mission you wanted to be on." He smiles at the memory. "Heady days."

It's been a long time since Krimigis, now director of the space department at Johns Hopkins University's Applied Physics Laboratory, has seen such possibility in the field of solar system exploration. Not that he hasn't

enjoyed himself over the past three decades. His career reads like a short history of the planetary program: principal investigator on the Voyager flights of the 1970s and '80s, co-investigator on the Galileo Jupiter mission, principal investigator for the upcoming Cassini expedition to Saturn.

But Krimigis and many of his colleagues feel that something has gone deeply wrong with their field, with the whole space program in fact—it's become bloated and bureaucratic and mired in politics. Things have to change, they say. It's time to get back to the way it used to be—small and simple.

Throughout NASA these days, managers repeat three words like a mantra: "better, faster, cheaper." In every viewgraph presentation, every program review, every speech by Administrator Daniel Goldin, the message is the same. Decade-long, multibillion-dollar projects are out. Lean machines are in. Small spacecraft, which until recently were relegated to student experimenters and amateur radio groups, are now becoming the favorite tools of the U.S. space program. All three solar system missions now seeking funds and planned for the end of the decade will rely on small spacecraft. A Martian lander, an asteroid observer, and a pair of probes bound for Pluto will all together weigh less than one of the Voyager spacecraft launched 16 years ago. Even large projects that were already in the works, like the Earth Observing System and the Advanced X-Ray Astrophysics Facility, have been scaled back or broken into smaller, more affordable pieces.

One reason that space scientists are building smaller spacecraft is that they can. Tinier and cheaper electronics, the same miniaturized circuits that have turned desktop computers into notebooks and "palmtops," have made it possible to launch fairly capable spacecraft that you can hold in your hands.

The other reason is that they have to. Despite the high-profile success of recent missions like Magellan's spectacular mapping of Venus, NASA's solar system exploration program has been on a collision course with the effort to shrink the agency's budget for several years. While some agency managers continued to propose ever grander and more expensive projects, Capitol Hill became increasingly reluctant to pay for them. The conflict reached a head last spring when Congress, already angered by cost overruns on the Mars Observer mission launched in September, forced the cancellation of the Comet Rendezvous/Asteroid Flyby spacecraft and pressured the agency to reduce the scope of the 1997 Cassini expedition to orbit Saturn and land a probe on one of its moons, Titan.

The traditional way to attack risk is to add more inspectors, more layers of oversight, and more cost.

Now almost everyone in the field agrees that billion-dollar planetary missions are no longer politically viable. But even if money were flowing freely, large space projects have inherent problems that make the switch to small missions a good idea anyway.

NASA's approach to designing planetary missions in the 1970s and '80s was to build very large, complex spacecraft with a dozen or more cameras, spectrometers, and other sensors attached. For missions like Voyager, a once-in-a-lifetime opportunity to visit four planets in one shot, it made sense to pile on as many instruments as possible. The two Voyagers had 10 instruments each, not counting their telescope-equipped video cameras. The same case might be made for Galileo and Cassini, which are long-term, comprehensive surveys of the Jupiter and Saturn systems.

Defenders of big, "facility class" spacecraft argue that these missions produce the greatest scientific return. "I'm not a subscriber to magic," says Louis Friedman, a former engineer at NASA's Jet Propulsion Laboratory and executive director of the Planetary Society. "I don't think there's a way to get more science by spending less. At some point, you give up something."

But the more science instruments there are on a spacecraft, the more costly the project becomes. Any savings gained by having many different instruments share power, communications, and other basic needs are offset by the expense of coordinating all the experiment teams and getting all the hardware to work in concert.

Because large missions cost so much, there are fewer of them, which means dwindling flight opportunities for scientists. As a result, says David Black of the Lunar and Planetary Institute in Houston, it becomes even more important to researchers to be included in the few missions that make it into NASA's budget. "Everyone says, 'This is the last bus leaving town—I'd better get on it,' " he comments. As more science requirements are heaped on, the price grows even steeper, and pretty soon the project is delayed or, like CRAF, killed. Scientists who've spent years preparing for a mission suddenly find

themselves with nothing to show for it.

Another reason large projects like Galileo and Cassini have so much trouble containing their costs is an almost obsessive attempt to eliminate risk. On a large, bureaucratic project, the traditional way to attack risk is to add more inspectors, more layers of oversight, and more documentation requirements, not to mention costlier, almost fail-safe instruments as well as backup systems. "We have become so afraid of failure," says Black, "that when you send a spacecraft to do a mission, the cost gets driven up immensely, because of a desire to make the thing 99.9 percent failure-proof."

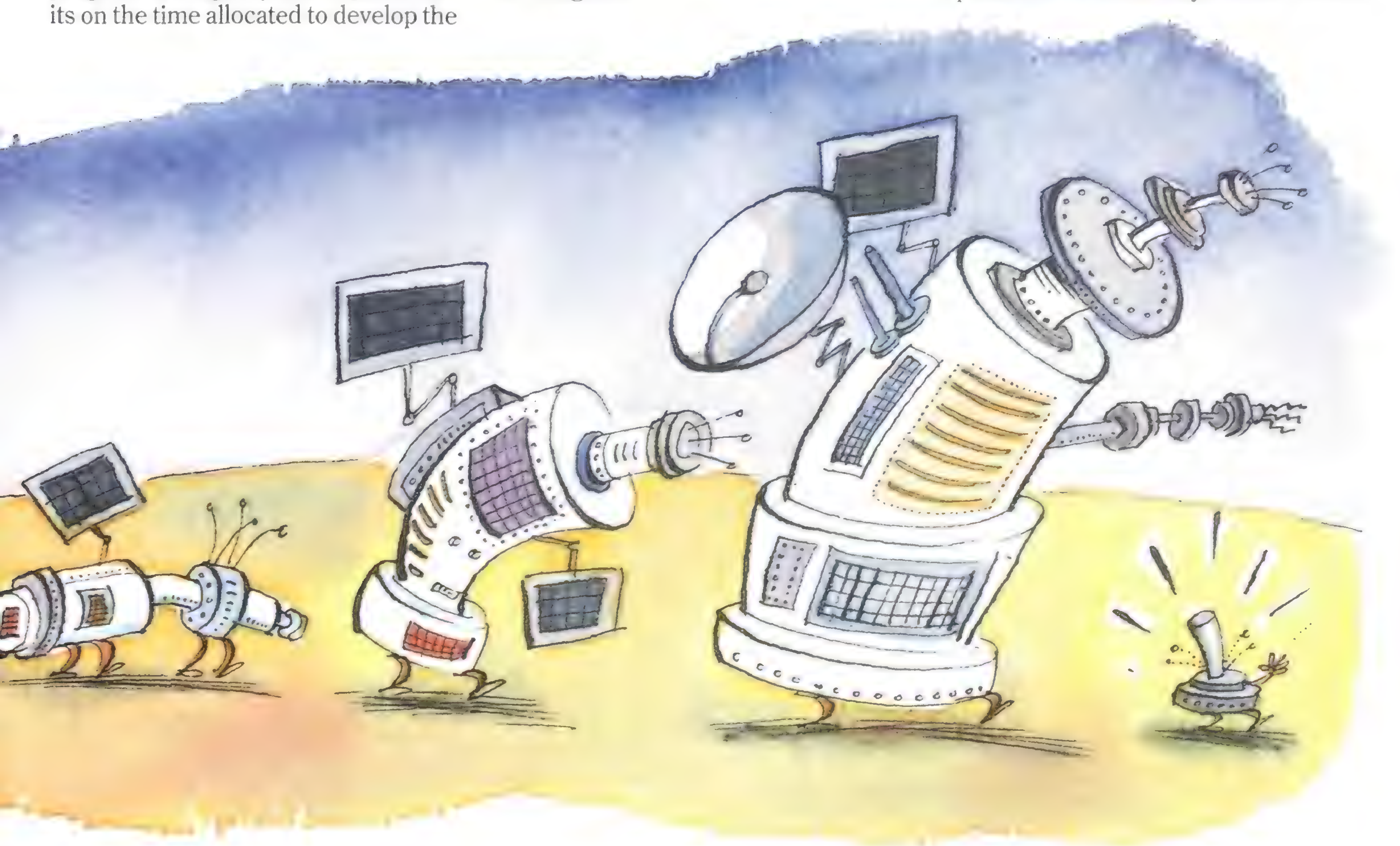
Wes Huntress, who heads NASA's space science division, recognizes many of the problems that have afflicted large planetary projects—the spiraling costs, the expanding science requirements, the excessive oversight. He believes NASA has found the remedy to those ills in a new program proposed to Congress last year. The new class of solar system missions, called Discovery, limits costs to $150 million per flight—cheaper than any past planetary program. The agency also imposed limits on the time allocated to develop the spacecraft—three years from start up to launch—and on their size. In order to keep the launch costs down, the craft must be small enough to make its trip with a push from a Delta rocket.

Congress funded studies for the first two Discovery missions: a small Martian lander called the MESUR (Mars Environmental Survey) Pathfinder and a mission to orbit an asteroid, both of which are to fly in the late 1990s if funding is continued. The latter spacecraft, called NEAR (Near-Earth Asteroid Rendezvous), is to be built by Tom Krimigis' space department at Johns Hopkins, the first time that a U.S. solar system mission is being designed outside NASA.

That point is not lost on Krimigis or the rest of the planetary science community. NASA's Jet Propulsion Laboratory has had a virtual monopoly in the field of solar system exploration ever since it built the first U.S. planetary spacecraft, Mariner 2, in 1962. One of the most important benefits of small planetary missions, many scientists say, would be to provide some friendly competition for JPL and allow more players in the game.

No question, the contenders are out there. When NASA solicited ideas for Discovery missions last year, nearly 100 proposals poured in. There were small comet missions, small asteroid missions, small moon missions, small missions to Mars, to Venus, to Mercury, to Jupiter's moon Io, even a proposal to put a $5 million camera-equipped satellite in orbit around the moon as an educational project. The proposals came not only from NASA centers but from universities, non-NASA government laboratories like Los Alamos National Laboratory, and private industry.

It may appear that in its pursuit of smaller spacecraft NASA is taking a cue from the private sector. A dozen companies are proposing to launch fleets of smallsats for the next generation of global communications. The most ambitious of these proposals, Motorola's $3.5 billion Iridium system, is a constellation of 77 smallish satellites intended to orbit Earth in a complex arrangement of 11 polar orbits. (The network gets its name from the element iridium, an atom with 77 electrons orbiting its nucleus.) In fact, NASA's approach is in some ways more revolu-



tionary than that of the private companies. The little armies of comsats are not replacing the older generation, which are 18,000 miles farther away and just as big as they always were. The newer systems are intended to perform in a completely different way—providing telephone, message, or paging communications from anywhere, not just those places where there's a phone booth. NASA, on the other hand, is trying to get small spacecraft to do the same jobs their bigger forebears did. In order to do that, the major change won't be in the size of the spacecraft bus. The real revolution is in the philosophy behind the research.

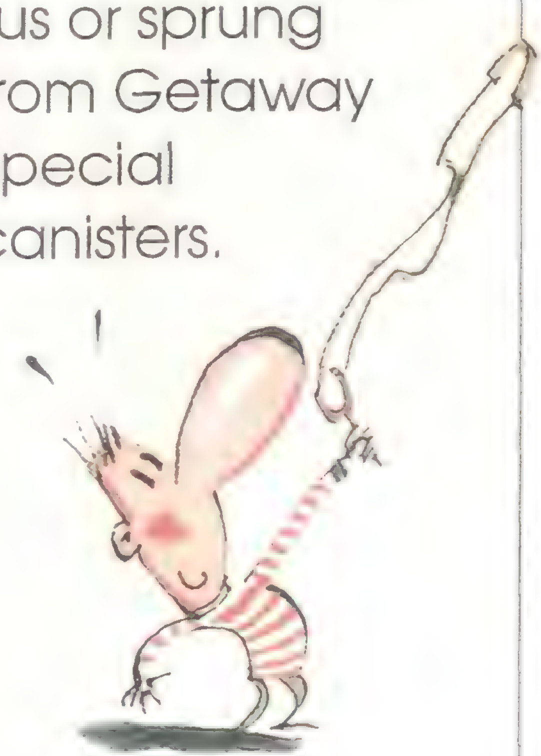
The ruling question asked in Discovery missions is not "How can we get the greatest scientific return" but "Given this cost and this time, what scientific results can be gained?" The only variable, says Wes Huntress, is the scope of the science. In order to get the most science for the money, Discovery science teams will have to run projects their own way, with a minimum of bureaucratic oversight from NASA and as little time as possible wasted on paperwork and meetings.

That suits the Discovery proposers just fine. "You save money by going fast," says Alan Stern, a planetary scientist with the Southwest Research Institute in San Antonio, Texas. "Instead of getting a marching army together and having them do a little bit of work every year, you should get a small number of people and let them go like hell."

If Discovery succeeds in creating a line of smaller, more frequent planetary missions, it will encourage innovation and creative risk-taking in a field that badly needs it, say many scientists. "It changes your entire approach to a project if you can allow yourself to fail," said Jim Stuart, a consultant and former JPL manager, at a recent gathering of smallsat builders. "When you fly a lot of inexpensive missions, you can allow a couple of strike-outs, because you're going to launch six of them this year. That means you can take some risks too, and go for some out-of-the-ballpark home runs."

When managers talk about taking risks, they mean the risk of a degraded scientific return. Using cheaper classes of parts and subsystems could mean

Spacecraft using ultra-tiny components could be orbited on cheap launchers like the Pegasus or sprung from Getaway Special canisters.



settling for a lower performance from the spacecraft. But risk also means the freedom to try new approaches or technologies that might pay off in weight savings, performance, or both: propulsion systems no bigger than a thermos bottle, high-density electronic packaging that eliminates the need for cables, mini-lasers for optical communications. Managers of big, expensive missions simply don't gamble on an unproven new device, not when a decade of work and a billion dollars are at stake. "You don't go for home runs on Mars Observer," said Stuart. "You just want to make sure you don't screw up."

That play-it-safe mentality, as well as the many years required to develop a spacecraft like Cassini, doom any large space project to being perpetually behind the times and to flying instruments that are outdated before they reach space. "The technology's changing so fast now that by the time you thoroughly space-qualify a component, you really don't want to use it anymore," said Stuart. "It's too old. Galileo doesn't have the power of my desktop computer."

Military space agencies have been

quicker than NASA to recognize this problem, and have spent the past several years developing new batteries, thrusters, guidance systems, and other components that can drastically bring down a spacecraft's weight—and therefore launch costs—while at the same time improving performance. Now those agencies are ready to start testing some of their exotic new hardware in space, using cheap, quick, low-risk—and small—spacecraft. In fact, the first planetary mission to push the art of miniaturized spacecraft technology will be sponsored not by NASA but by the Strategic Defense Initiative.

Officially, the proposed $80 million Clementine project is just a test flight to demonstrate the space-worthiness of new, lightweight sensors, computers, and other components. But, with NASA participating as a science advisor, SDI managers have cooked up something a bit flashier than the usual hardware test. The spacecraft, which weighs less than 350 pounds, or one-tenth what Galileo weighs, will first fly three loops around the Earth-moon system, exposing the instruments to different radiation levels. Then it will orbit the moon for two months, using infrared, visible, and ultraviolet sensors to gather information on lunar geology and chemistry. In August 1994 Clementine will fly past the asteroid Geographos, testing a sophisticated autonomous navigation system as it approaches. Using its onboard cameras and computers, the spacecraft will lock in on the asteroid and update its own course, much as a "smart" interceptor would adjust its course while closing in on an enemy missile.

NASA engineers have already shown interest in some of the new SDI components. JPL is developing its own miniaturized technology as well, says Rex Ridenoure, who heads a JPL task force that's building a testbed "micro-spacecraft" weighing less than 110 pounds. The gadgets range from miniature startrackers and gyroscopes to compact imaging systems. Spacecraft using these ultra-tiny components could be launched on very small, cheap launchers like the Pegasus, or could even be sprung from Getaway Special canisters in the cargo bay of the space shuttle. "We're pretty sure that in the next five years or so,

we can figure out how to make a planetary spacecraft weighing on the order of 35 kilograms [75 pounds] that can do something very useful," Ridenoure says.

Even though it doesn't qualify as a micro-craft, another concept under study at JPL could be the most exciting small planetary mission of all: a flyby of Pluto, the solar system's last unexplored planet. The design calls for a pair of small probes weighing about 350 pounds—one-fifth the weight of a Voyager—that could reach Pluto in as little as seven years if they were launched on a direct course by a giant Titan booster or a cheaper Russian Proton. It would take as long as 18 years for a Cassini-size spacecraft to make the same trip.

According to Wes Huntress, sending small spacecraft to make the first reconnaissance of Pluto is a throwback to the "Mariner style of doing business." Of course a 350-pound spacecraft today can accomplish a lot more than it could have 30 years ago. "The technology has advanced significantly," says Huntress, "so that instead of getting little postage stamp pictures across a very tiny portion of the surface, like Mariner 4 did at Mars, we can do global imaging at high resolution."

Robert Staehle, the engineer who's leading the Pluto fast flyby development at JPL, compares the size of his spacecraft to "a coffee table with a garbage can attached to the bottom." The entire science payload will weigh only 15 pounds—less than one-third what a Cassini camera alone weighs. That kind of tight margin will sorely test the self-discipline of the science teams who want to fly experiments on the historic mission. But Alan Stern, who chairs the scientific working group that advises NASA on outer planet missions, says that after some "bloodletting," the group was able to reduce their wish list of recommended experiments to only four essential ones: a camera, infrared and ultraviolet spectrometers, and a radio science experiment.

At the meeting where the scientists endorsed the Pluto mission, "there was a very, very positive attitude, like a breath of fresh air," says Stern. "We voted almost unanimously that this was the way to go and that we shouldn't do things the old way, which is to send a battleship when a schooner would do."

But there will be hazards along the way, starting with a NASA culture that isn't yet accustomed to letting a small team go at a project unencumbered by managerial oversight and mounds of paper. After all, this is the same agency that has been trying for 10 years to build space station Freedom, the antithesis of "better, faster, cheaper." Many scientists worry that the "small is beautiful" spirit behind Discovery will become corrupted.

"Unfortunately, the history says that we start these small missions and before you know it, NASA headquarters and the scientific community, working in cahoots, blow them up into big, expensive missions and they end right there," says Michael Belton of the National Optical Astronomy Observatories, a principal investigator on the Galileo mission who has submitted a Discovery proposal of his own. The Mars Observer, for example, started as a $300 million project. It ballooned into one costing $511 million.

The scientists have a right to be skeptical, admits Wes Huntress, until Congress and NASA prove that they really can sustain a small, focused program like Discovery. "The planetary science community has been gloomy for a long time," he says. "They've been kicked around a lot, and they only had one mission in the '80s—Voyager. So they tend to be pessimistic, with a 'show me' attitude."

The way to make Discovery work, he says, will be to insist on discipline and efficiency from those very scientists and engineers. "You strictly limit [the missions] to time, and you strictly limit them to cost, and you have the guts to cancel projects if they fail to meet those marks."

The people who are most excited about small spacecraft tend to be young—Ridenoure, Stern, and Staehle are all in their 30s—and tend to have, somewhere in their backgrounds, experience with small, hands-on space projects. Before he came to JPL to work on the Voyager Neptune encounter, Ridenoure was developing small shuttle payloads for a startup company in Utah—that is, before the *Challenger* accident "threw our whole business plan back to square one." Staehle heads the World Space Foundation, a mostly volunteer group based in Pasadena, California, that plans to launch a solar sail into space.

All of these young engineers and scientists would like the chance to fly regular missions, the same chance Tom Krimigis had, half a lifetime ago, when the spacecraft were small and the planets were still unexplored.

Says Alan Stern: "Instead of getting a marching army together, get a small number of people and let them go like hell."

Ridenoure remembers an old hand at JPL who had worked on the Ranger missions of the early 1960s telling him how exciting it had been to fly one moonshot after another: "He'd leave for work on a Friday morning with a sack lunch and a sleeping bag, kiss his wife goodbye, and say, 'I'll see you Sunday evening when the mission's over.' And then a few months later they'd do another one."

Ridenoure shakes his head. "It's not that way anymore."

But Tom Krimigis well remembers that spirit and hopes that Discovery will keep it alive for a new generation of scientists and engineers.

How long is a Backfire?
How many seats in a Hokum?
For answers to these questions
and others...

ASK JANE'S

by Joshua Jampol

Photographs by Christopher Cormack

Coulsdon is a sleepy town in Surrey, England, about a half-hour's ride from London. Its main street shops are everything you'd expect from a quiet, middle-class English burg: There's an Indian restaurant, a Woolworth's, Coulsdon Hardware ("The family store that offers you more"), and the news agent's. There is, however, one surprise. Nestled between Bob's Bikes and the Red Lion pub sits the world's most sophisticated arms information network. Like state-of-the-art missiles poised in the peaceful plains of the American Midwest, the world's top weapons watchers sit in the heart of a leafy London suburb.

Coulsdon is home to Jane's Information Group, publishers of such military chronicles as *Jane's All the World's Aircraft, Jane's Fighting Ships,* and *Jane's Defence Weekly.* Each year Jane's publishes 24 yearbooks and four magazines stuffed with the latest statistics and information on all the hardware in aerospace, military, and transportation, including general aviation and military aircraft, airliners, ships, ammunition, artillery, infantry, naval and air-launched weapons, railways, radar systems, electronic and underwater warfare systems, avionics, space markets, and intelligence. In *All the World's Aircraft* you will learn that Taiwan's AIDC Ching-Kuo single-seat air superiority fighter has a Golden Dragon 53 multi-mode pulse Doppler radar with a range of approximately 93 miles. *Defence Weekly* will tell you that the U.S. Air Force has a fleet of twenty $1 billion Lockheed spyplanes powered by liquid methane and capable of cruising at Mach 8 at 130,000 feet. *Airport and ATC Equipment* notes that Elektroimpex's Visinform flight information system displays Roman, Arabic, Greek, or Cyrillic characters and numerals on a multicolored five-by-seven or six-by-eight dot matrix, and that it is currently in service at Moscow-Domodedovo, Vnukovo, and other Russian airports. And in *Air-Launched Weapons,* you'll learn that Argentina's Mamboretta 657 unguided rocket launch-

Under orders to modernize, Mark Lambert, the fifth editor of Jane's All the World's Aircraft, *slimmed down the 1992 yearbook by 50 pages, but says, "We didn't lose a fact." Users can gain access to Jane's voluminous data collections through CD-ROM as well as in traditional form (right).*

er can be purchased with or without an intervalometer for ripple firing.

Jane's, revered for its credibility and impartiality, neatly catalogues the information on which governments, armies, industry, and rivet counters depend. Its reputation is so well established that when diplomats at Conventional Force Reductions talks in 1990 disagreed on the details of various weapon systems, they turned to Jane's volumes as arbiters. The reputation explains why some 600 copies of *Defence Weekly* are delivered to the Pentagon and why General Norman Schwarzkopf had it delivered to his bunker during the Gulf war. It's why scientists at Russia's TsAGI aerospace research institute turned to Jane's for information on a Tupolev Tu-22M Backfire they were testing when the air force, citing security, refused to give them any details on the bomber. The reputation for accuracy is "an awful legacy," says *Defence Weekly* publisher Paul Beaver. "It means you have to be good, all the time."

The awful legacy was handed down from founder Fred T. Jane, an artist and naval enthusiast who set the standard when he compiled *Jane's Fighting Ships* in 1897. New editions have been published yearly since. In 1909, after Louis Blériot crossed the English Channel in his monoplane, Jane produced *Jane's Air-Ships,* which in time became *Jane's All the World's Aircraft* and today enjoys a circulation of some 277,000.

What started as a one-man fact-scrounging hobby has burgeoned into a data deluge that brings Jane's $40 million a year. Offices in Washington, D.C., and Los Angeles, regional bureaus in Paris, Bonn, and Bangkok, and a global network of 300 correspondents inundate Coulsdon's aptly named Sentinel House with a torrent of trivia. Though the bulk of information comes from manufacturers, governments, and the military, modern-day enthusiasts provide a respectable share of the fact flood. Fans used to snap photos of Soviet military parades. Amateurs today still fill the mailbox with 50 letters a week from Rotterdam, Halifax, and North Carolina, where, binoculars in hand, they hang around shipyards and skunkworks and take note of objects that otherwise might not come to the editors' attention.

Jane's is open to all input. "My small-arms consultant is a llama breeder," says Rupert Pengelley, editor of Jane's *International Defense Review.* "But he has proved to have phenomenal contacts in the small-arms business."

When Jane's professional sources deliver, they do so with style. For some time, Jane's editors had known about the Royal Air Force's Airborne Early Warning Nimrod, originally a maritime patrol aircraft that had been modified for electronic intelligence gathering, but they could never get a photo of the revamped AEW airplane from the tight-lipped RAF. In 1978 *All the World's Aircraft* editor John Taylor mentioned this to friends in the Swedish air force, who photographed the bulbous Nimrod from the air, printed it in a restricted-circulation air force magazine, and promptly sent the print to Taylor.

The military is a reliable inputter, since they use the books and want to keep them accurate. Private companies, however, sometimes mistake Jane's for a marketing tool. Christopher Foss, who edits four yearbooks, says that rewriting the builders' text inflames some overly enthusiastic firms. "You have to be careful to avoid being used," he says. Both French and U.S. companies, he adds, have been guilty of giving Jane's specifications that didn't match what was in the Coulsdon files.

John Taylor's memorabilia reflect his 30-year editorial reign at All the World's Aircraft. *Though Jane's is headquartered in rural Coulsdon (right), most yearbook editors follow Taylor's tradition of working at home.*

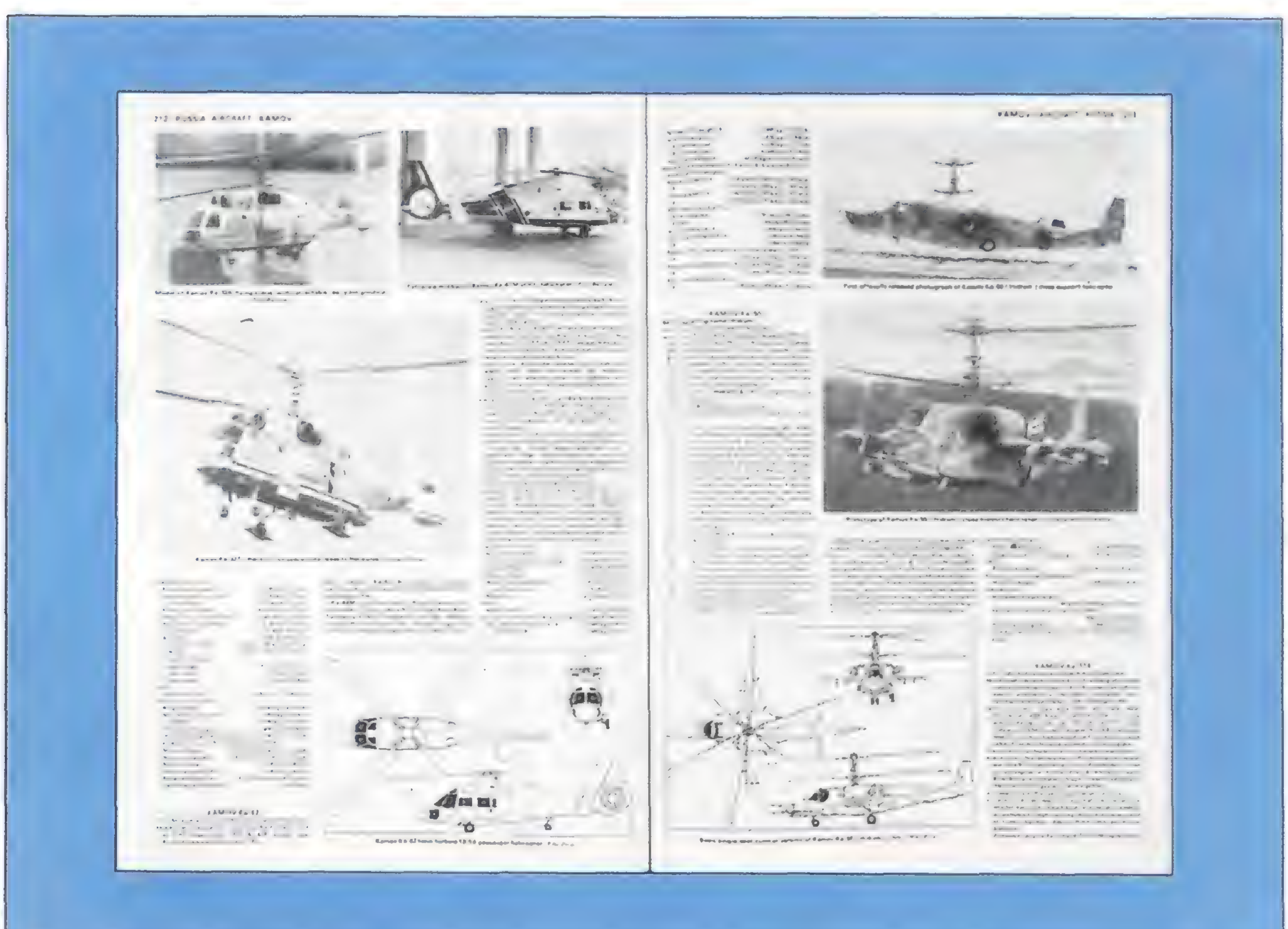
But before the info glut becomes gospel, before the books are covered with coffee, oil, and water stains, the incoming facts must first wend their way through Sentinel House's sifting machine. Coulsdon is staffed with 260 editors, journalists, proofreaders, and specialists in all branches of warcraft. Some are former military officers, others are backroom technical types. Richard Sharpe, editor of *Fighting Ships,* once commanded a nuclear submarine. John Taylor, for three decades editor of *All the World's Aircraft,* designed airplanes for Hawker and Fairey. His successor, Mark Lambert, is the first pilot to edit the aircraft yearbook. Regardless of credentials, "we don't just trust our own specialists," says Paul Beaver. "We check them too."

When the commander-in-chief of the Indonesian Air Force told Beaver last August that his country was considering getting into the ballistic missile business ("A major turnaround from its defense policy," the publisher observes), Beaver wrote a first draft and sent it to the *Defence Weekly* news desk. Simultaneously, Beaver tapped sources in London who keep close tabs on the Asian scene. *Defence Weekly* specialist editors, who cover air, land, and sea, began checking their yearbooks and the vast Jane's database. When the news editor verified the story with the Indonesian Defence Ministry through Jane's Bangkok office, the story was considered eminently printable. *Defence Weekly* ran the Indonesia piece last September, reporting that the country was indeed looking into purchasing Scud missiles from Russia. By the time the September 5 issue was in print, a similar story had surfaced on the estimable British Broadcasting Company's World Service in southeast Asia. Rather than considering themselves scooped, *Defence Weekly* editors felt that the BBC release simply enhanced the credibility of their breaking story.

When deciding what gets printed, Jane's tries to avoid two things. One is putting the lives of people in uniform at risk. "We do not want to print infor-

mation which is going to make life easier for the bad guy," says Richard Sharpe. The other thing the editors steer clear of is prosecution for violation of Britain's Official Secrets Act. Jane's says it's always interested in a good, relevant news piece, but not if it will incur the wrath of Her Majesty's government.

Shortly after the 1983 Falklands war, Paul Beaver learned that during the conflict Britain's Royal Navy had developed a "laser dazzle sight," a low-power laser that ships could activate to distract or even temporarily blind attacking pilots. Beaver approached the powers that be to inquire about the device and was told that the LDS was strictly classified—"only a handful of people knew about it," he says. He obediently stowed the story in the back of his mind until it surfaced in a Spanish magazine six years later. Beaver then contacted the chairman of the dread "D notice" committee. The D (for "Defence") notice is Britain's voluntary-restraint system for journalists. A Ministry of Defence committee advises publishers: If you have something you feel could contravene security, ask us. So Beaver asked. Could he now publish the laser dazzle story? The chairman bobbed and weaved, telling Beaver that doing so would not necessarily trigger a prose-



A sampling of Jane's Greatest Hits (above, left to right): first photos of the Sukhoi Su-25 "Frogfoot" ground attack aircraft, 1983; first accurate three-view of the MiG-31 "Foxhound" fighter, 1984; first photos of the Chinese Navy's Harbin PS-5 patrol and anti-submarine bomber amphibian, 1987; and (left) first photos of the Kamov Ka-50 "Hokum" close-support helicopter, 1992.

cution, but he could not guarantee that it was outside the terms of the Official Secrets Act. "It was that sort of situation," Beaver sighs. "We went ahead and ran the story, and we're still here. But we showed six years of restraint."

That's not to say Jane's is unfailingly deferential in all matters British. For instance, *Defence Weekly* refers to "The Falklands (Malvinas)," even though the wording drew a barrage of irate letters from patriotic Brits who objected to the Argentine nomenclature.

For an outfit selling credibility, good contacts are life's blood. Some have proved troublesome, of course. In 1984, Samuel Morison, a U.S. naval military analyst angling for a job at Jane's, sent *Defence Weekly* photos of the Soviets' first full-scale nuclear-powered aircraft carrier sitting in a Black Sea shipyard. The shots, taken by a U.S. KH-11 reconnaissance satellite, were classified, but *Defence Weekly,* unaware of that, published them in the August 11 issue. When the British Defence Intelligence director came looking for the photos, which bore Morison's fingerprints, Jane's learned that Morison was to be prosecuted for espionage.

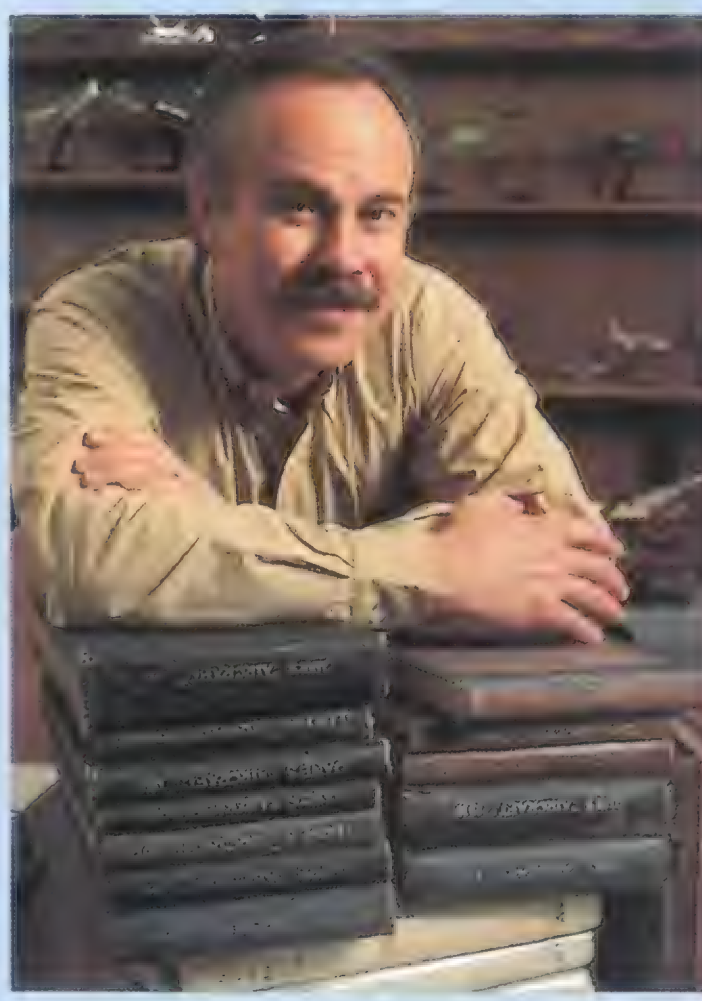
If the Morison affair put Jane's on the map, the Gulf war lofted it into the firmament, doing for Jane's what it did for CNN. During the first five days of the conflict, the world's media inundated Coulsdon with a thousand inquiries. Phones were jammed around the clock with questions like "What's the weapon load of a Tornado GR.Mk I strike aircraft?" A TV studio was set up in the library. "I thought I was running a multimedia outfit," says group managing director Michael Goldsmith. "We had to restrict our TV appearances to carry on our daily business."

In normal times the library is the end of the line for most of the information that streams into Coulsdon. Derrick Ballington, chief librarian, admits to being "well past retiring age" but commutes 70 miles a day because he loves his work. He was asked to organize a library in 1983—unbelievably, Jane's didn't have a proper archives. "We had half a dozen books and 50 photographs," he says. Now the ex-cartographer is in charge of 2,000 volumes and what is probably the largest stock of military

Book of the Year Club

As an aviation writer, I often use *Jane's All the World's Aircraft* as a starting point for technical descriptions of hardware. The discrepancies between Jane's entries and the manufacturers' releases are frustrating at times, but because of the book's stature, one cannot easily discount its figures.

Such respect has increased the book's collectibility. The 1909 book sold for $8.40, but if you aspire to add the premier volume to your library today, it'll cost you $800—if you can find a copy. To collectors of Jane's, however, the Holy Grail is a complete set of 79 volumes. It's estimated that there are no more than 30 complete sets of originals extant. Only a handful are in private hands; the majority are in institutions and often inaccessible to the public.



DAVID NANCE

Several companies, most notably Johnson Reprint and Arco Publishing, have reprinted some of the rare early editions. However, the reprints have become collectibles themselves. Their prices are climbing in concert with their first-edition cousins; $100 for a well-cared-for reprint is not uncommon. Particularly in demand are the rare Johnson repros, which encompassed 1909 through 1923. These differed from the originals in having the advertising sections deleted, a concession to printing economics.

For non-purists on limited budgets, the Taiwanese printing industry has provided an affordable—albeit illegal—compromise. Copyright-infringing Taiwanese reproductions of recent volumes have surfaced, notable for their poor reproduction standards and in some cases the expurgation of the politically sensitive Chinese section.

Jane's All the World's Aircraft has been published in other countries, but with the legal issues properly addressed. Van Nostrand, Macmillan, and McGraw-Hill successively published U.S. editions from 1914 through the late 1960s. In 1970, all distribution came under the auspices of Jane's Information Group.

My set is the cornerstone of a 5,000-volume aerospace library compiled over some 40 years. My first *All the World's Aircraft,* the 1962/63 volume, was a birthday present from my father. It was followed by all available facsimile editions and a mix of U.S. and British originals. After 10 years I had most of the original books back to about 1945, but everything of earlier vintage was a reproduction.

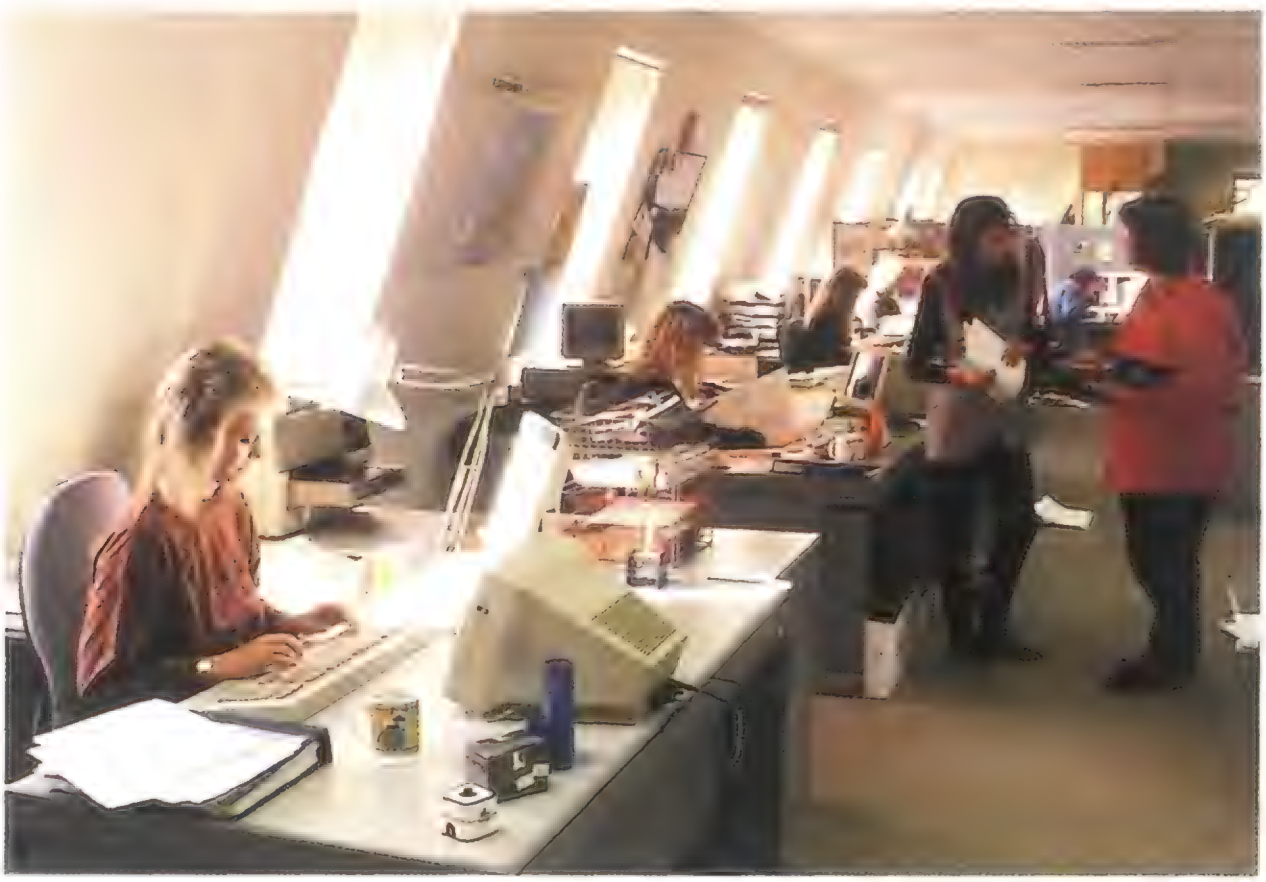
In 1974, I happened upon a three-line ad in an aviation enthusiast quarterly. A collector in New Zealand was selling a nearly complete set of original editions. I took out a $4,200 loan, and three months later I opened a massive wooden crate containing what would prove to be the best investment I ever made. I immediately sold my old hodge-podge set, paid off the loan, and custom-built a set of shelves. I've added new volumes yearly since, and today my collection, if for some unimaginable reason I would ever consider selling it, could bring as much as $65,000.

—Jay Miller

Some 260 editors, proofreaders, and production staffers put Jane's publications together at Coulsdon, but the information they compile comes from a worldwide network of correspondents tuned in to hardware gossip.

pictures in England. Though he has never catalogued them (he never throws anything out either), he reckons he has 50,000 photos in the rows of filing cabinets lining one end of the library. There are three drawers alone marked "NATO Ships."

The phone brings inquiries from around the world. By 11 a.m. one morning Ballington has fielded a call from an Italian publisher who wants to know if Italy is reconsidering the beleaguered European Fighter Aircraft and buying F/A-18s instead, and he has responded to a caller who had faxed a photo in which one can barely make out a man in a cockpit. "Looking back through the books from 1910 to 1912, we were able to identify that plane for him," says Ballington. "We also found a photo of the chap, so there's another satisfied customer."



Coulsdon is the management, magazine, and marketing core of Jane's, but it is not where the yearbooks are made. With the exception of *All the World's Aircraft* editor Mark Lambert, the yearbook editors work at home. Tucked away from the road and ringed by Hampshire's green fields and dairy farms, Richard Sharpe edits Jane's crown jewel, *Fighting Ships,* at his quiet home in Alton, near Farnborough. Other yearbook editors manage similarly, linked by modem to the Coulsdon database. "We all work with lovely views on our gardens," Sharpe says.

For much of the time, editors say, theirs is a civilized job: drafting new questionnaires and scrutinizing completed ones, handling correspondence, combing the international press. The updating periods, however—November to April—are chaotic. Recalls Sharpe: "I thought: 'Updating *Jane's Fighting Ships*? Well, there are a lot of pages, but a lot of things don't change. It won't be much of a job.' It's a horrific job!" Sharpe says he's lucky if he does eight pages a day. Each Jane's yearbook averages 800 pages, and each page contains some 350 items of information.

Home-based yearbook stewardship has not changed greatly over the years. When he held the aircraft yearbook's helm from 1959 to 1989, John Taylor worked in a study with 4,000 books and 180,000 pictures scattered throughout the house. When he began, Jane's published only three yearbooks, yet *All the World's Aircraft* had already reached one million words. Taylor spent 100 hours a week double-checking everything that went into the book, an attention to detail he attributes to his aerospace background. "My outlook is, you make a mistake and you can kill somebody," he says.

Today Taylor is responsible for the Russia and Ukraine sections of the yearbook, perhaps tougher to get right today than 25 years ago. But Taylor has

Thanks to chief librarian Derrick Ballington, Jane's now has a proper archive of 2,000 books and 50,000 photos. Ballington also fields inquiries from researchers, journalists, and enthusiasts via phone and fax.

a secret weapon. He has known all the greats, from Igor Sikorsky to Geoffrey de Havilland. "I have friends in every country that builds airplanes," he says. As editor he developed a string of Soviet relationships, and at the Paris Airshows he boarded Soviet craft with their pilots. He recalls going around the Su-27 with Sukhoi designer Nikolai Nikitin in 1989, updating his Jane's questionnaire. He didn't bother sending forms to the Soviet Union until 1991, preferring to rely on his web of contacts. "They told me, 'Ask any questions you like, we'll tell you. We'll also tell you what you can't publish.' I never broke our verbal contract, and nobody ever told me a lie," he declares.

When no information was forthcoming, Taylor used available photos to ferret out the truth. In 1981, a U.S. satellite photographed a new Soviet bomber, the Tu-160 Blackjack, at the Ramenskoye test center. It happened to be parked next to a Tu-144 supersonic airliner, whose length was known. Establishing the bomber's dimensions was a cakewalk—all Taylor had to do was pick up a ruler.

The geopolitical jumble that ensued when the Iron Curtain fell puts Jane's in the same jam every mapmaker faces. Both go to print and hold their breaths: Will next week's headlines blow all that work into obsolescence? At Coulsdon, where cold warriors die hard, Jane's is wary of the voluminous news feed emanating from Moscow and the republics. Taylor's experience notwithstanding, most editors say that after some 70 years of misinformation, the ex-Soviets still find it hard to tell the truth. Their bureaucracy is so inefficient, adds one editor, that half the time they don't know what the truth is anyway.

Taylor is the first to admit it's less of a challenge nowadays, with the cold war thawed out. "There's more information available," he says. "We don't need to estimate as much." Adds Chris Foss, "We had a pretty good idea before. Now the focus is getting the proper Russian name of an aircraft, as well as the NATO designation."

News congestion did finally catch up with the aircraft yearbook after the 1990/1991 edition, when the whole thing went under the knife to emerge, completely rewritten, for 1992/1993. It seems that *All the World's Aircraft* had developed a literary malignancy known as purple passagitis, which caused it to drift from Fred T.'s facts-only format toward something like, heaven forbid, "a good read." The prescription came down: *modernize.*

The remade yearbook was unveiled last September at England's Farnborough trade show. The more concise style saved 30 pages on the United States section alone. Though the book is a total of 50 pages shorter, editor Mark Lambert calls the latest issue the richest *All the World's Aircraft* yet. "Thirty percent more information!" barked the ads. "We didn't lose a fact," Lambert says proudly. Nor did Jane's lose any readers who fancied the flowery parts. "Our readers will get information more quickly, that's what I care about," says Lambert.

The yearbook charts 1,031 military, commercial, and private aircraft and contains 304 three-views plus 1,232 photos. Still, it's no longer true that "if it flies, it's in Jane's." "In the old days, if you built a plane in your back yard it would have gone in," John Taylor admits. "That's something we can't do anymore."

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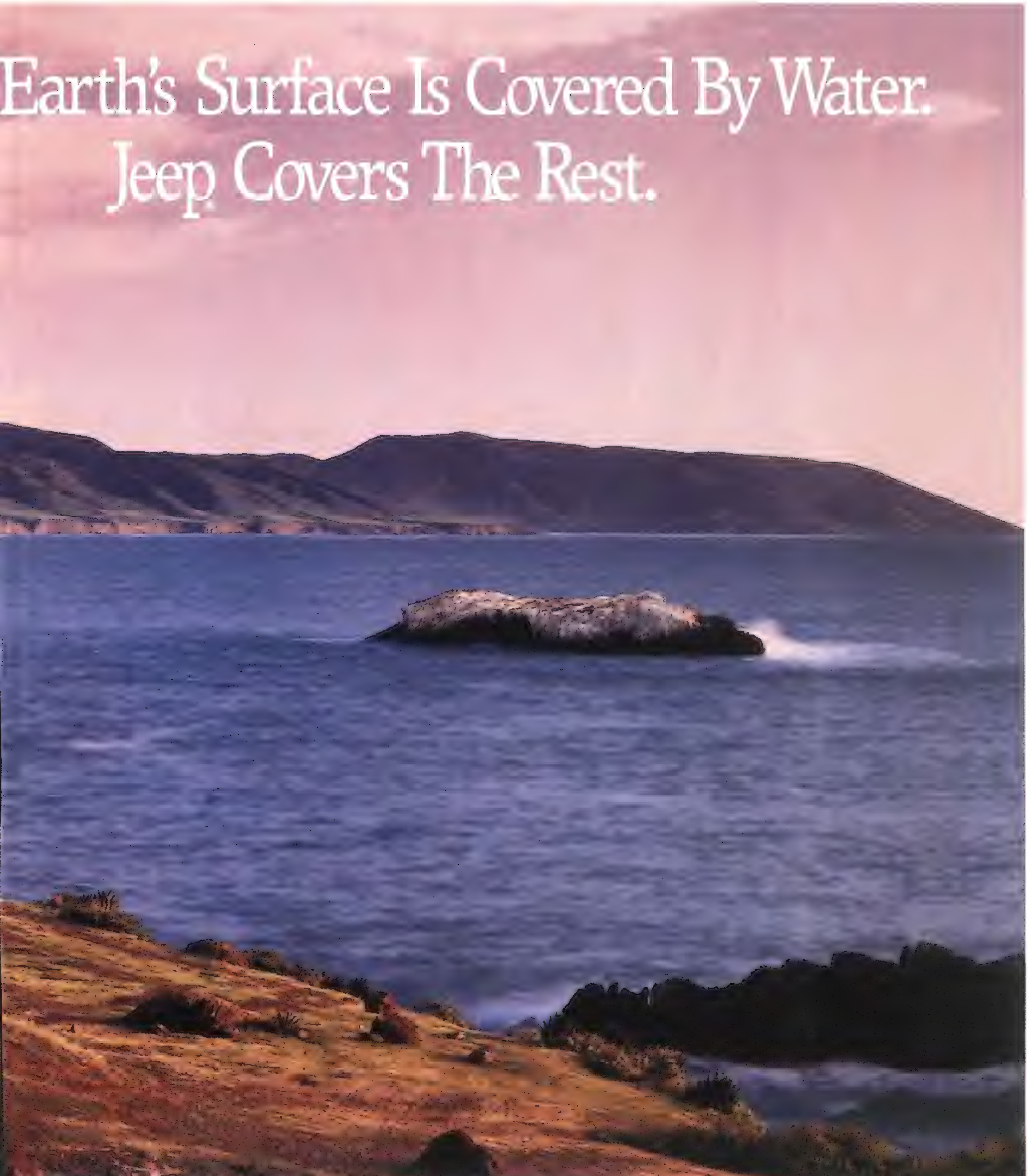

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CHARLIE AND THE AQUANAUTS

How a team of NASA employees made Huntsville, Alabama, the best place to learn about life without gravity.

by Homer H. Hickam Jr.

Color photographs by Alan S. Weiner

Every morning, Monday through Friday, Charlie Cooper enters Building 4705, a tall, metal shed-like structure standing on the western rim of NASA's Marshall Space Flight Center in Huntsville, Alabama. Quietly he pads his way to the dressing room in the rear of the building and changes into his running clothes. He no longer works in the facility, but he is allowed a small locker in homage to the pivotal role he once played there. Before he exits for his daily four-mile run, he passes a great gray cylinder rising more than 40 feet off a concrete apron. Bright blue portholes circle it at three levels. Cooper rarely glances in its direction, although it is the triumph of his professional life. Outside, his running shoes slap against the pavement as he leaves behind Building 4705 and its most remarkable invention—an invention that saved a billion-dollar space mission and may yet save another.

In 1965, Charlie Cooper was a 28-year-old electrical engineer working in Marshall's manufacturing engineering laboratory when he learned of a problem in the Apollo Applications Program, a series of spaceflights planned to take advantage of the big boosters and spacecraft left over from the Apollo moon program. All kinds of ideas had been proposed for the AAP, among them the creation of a space laboratory out of part of a Saturn V booster. An early scheme involved launching astronauts into orbit in a standard Apollo command module-booster system; once in space, the crew would step out of the command module, spacewalk up to the Saturn's S-IVB stage, and pull out its fuel tanks and other engine hardware, thereby preparing it for transformation into a space laboratory. But no one had ever attempted such heavyweight work in space before, and NASA engineers weren't certain it could be done.

Marshall had been assigned to design the tools the crews would need to gut the S-IVB, and Cooper's division held some brainstorming sessions on how exactly the mission would work. "Most of the managers were worried that if anything of any size was moved in zero G it would be pretty hard to stop and might go right through the wall of the spacecraft," Cooper recalls. "Well, I had an opinion just like everybody else and I thought it wouldn't be that hard to work in zero G. So I started to think of some way to prove it."

At the time, Cooper already knew a bit about the problems of working in challenging environments. As a teenager, he had thought about becoming an underwater explorer and had even built some diving suits. After graduating from the University of Evansville in Indiana and coming to Huntsville, he had learned how to scuba dive. More recently, he had served as a volunteer for a small office at Marshall that was studying spacesuit designs. He would put on various suits, get on a treadmill, and see how difficult it was to move. "When I looked at these spacesuits I kept thinking that these things would work underwater too," he recalls. "When this problem with the AAP came up I just put it all together."

The lab where Cooper worked had a small tank of water, eight feet across and eight feet deep, used for forming metal. There was also a heavy object available, a mockup of a 124-pound gyroscope similar to one that the AAP spacewalkers would have to move out of the S-IVB stage. In the spring of 1965, Cooper sold co-worker Charlie Stocks on his idea; when no one was around, the two went over to the sheet metal tank to try it out.

DENNIS KEIM, NASA

During his career, Charlie Cooper (above) has seen the technology of simulating weightlessness evolve from a few furtive dips in a small water tank to elaborate rehearsals of extravehicular activities in a huge 40-foot-deep facility (left).

Getting the heavy ball into the tank was a struggle. "We rolled it in and went in behind it," Cooper remembers. "Of course we didn't have a spacesuit to work with. We didn't even have wet suits, so we just stripped down to our skivvies. Lord, it was cold in there. There was a stopper in the ball that I could take out to let in water. I played with that, letting the ball fill up until it stabilized. Then I started to push it all around the tank. I could feel the mass of it but it didn't take much to move it and I could stop it very easily just by hauling back on it. The way I figured it was that we had just demonstrated that a big heavy object could be handled manually by a spacewalking astronaut.

"But now I had to figure out what to do next—how to get this news out," he continues. "What I had just done wasn't exactly in my job description."

Cooper's boss was Bob Schwinghamer, then the chief of the experimental electronics development branch. He had been traveling when his two employees conducted their experiment. Now Marshall's deputy director of space transportation systems, Schwinghamer recalls: "Well, as soon as I heard about it I wanted to try it too. It was my tank so I got that ball and just climbed in with it. Charlie was right. I could move it all around. I thought to myself, *This is something! We ought to do more of this!*" The next morning, Schwinghamer called Cooper and Stocks in and raised hell with them for trying their scheme without checking first. While they were absorbing their shellacking he told them to get busy. He would support the idea all the way.

As Cooper's supervisor, Bob Schwinghamer (above) firmly supported his employee's efforts to approximate zero-G working conditions. The early attempts quickly drew in other Marshall engineers (below; Cooper is fourth from the left).

It was clear to both Cooper and Schwinghamer that just going underwater with a mockup would not be enough to prove anything. What was really needed was for someone to get in wearing a spacesuit. Schwinghamer tried to get a suit through a contact in Houston, but that didn't pan out. "So I sent Charlie Cooper to the Navy base in Miramar, California, for high-altitude-suit training," he says. "I knew what he'd do and he did it. He talked those guys out there into letting him borrow two Arrowhead Mk IV high-altitude suits."

When Cooper brought the suits back, he and some coworkers designed a simple umbilical air supply line and prepared for a test dive. But there was one problem: inflated, the suits were extremely buoyant. Cooper and his co-workers decided to try weighing the suit down with small lead plates.

Other employees in Schwinghamer's branch volunteered to help during their off hours. It took them all night to pour the lead to create the plates. Then they borrowed a big pair of coveralls from one of the maintenance men and spent another night laboriously tying the plates on almost every square inch of the garment. In May they were ready for their first suit test. Cooper donned the Arrowhead suit, then the coveralls. When he was finished dressing, Cooper recalls

NASA (3)

with a grin, "I was so heavy I couldn't stand up. That was embarrassing. But the other guys grabbed me and dragged me to the tank and kind of slid me in. Before I got in the water the suit felt like it was going to break my back, but after I got in it felt just fine."

Cooper pushed away from the ladder, the only sound the air rushing through the umbilical and the blood pulsing in his ears. The first thing he noticed as he started to move around was how easy it all was. He turned, grasping the ladder and rotating until he was upside down. His boots swung up effortlessly.

In subsequent tests, the group found that they didn't need all of the lead plates. By adding and subtracting weights, they trimmed Cooper out so that he was neutral no matter which way he turned. Still, dives in the tank would never replicate the weightlessness of space perfectly. Explains Schwinghamer: "There is some fluid friction [in water] you don't have in space." Generally, the more rapidly a person tries to move in water, the more the water's viscosity will resist his movements. However, if the person slows his movements, he can diminish the resistance. Since most real spacewalks are themselves done slowly, they can thus be simulated quite realistically in water.

During the second year of the informal program, Marshall director Wernher von Braun's support enabled Cooper and his team to carry out their trials in a larger tank (above; Cooper is at right). The far-sighted von Braun immediately perceived the value of neutral buoyancy training; in 1969 he tried it for himself (above right).

Cooper and his crew were making great strides, but their research was all very low key, and without support from the top, it would all be worthless. Fortunately for Schwinghamer and Cooper, Marshall's director, the renowned rocket scientist Wernher von Braun, quickly became a powerful supporter of the tank experiments. Because of von Braun's support, Schwinghamer was allowed the use of a better tank, a 15-foot-deep facility once used for forming parts.

A small group of engineers and technicians, still all volunteers, began coalescing around the effort, offering an assortment of useful skills. One early participant, Marshall engineer Joe Dabbs, contributed his expertise as a scuba instructor. Dabbs taught the group how to dive, then took them all down to Florida for their checkout dives. In the process, he began diving with them. "For a time I left NASA and transferred over to the Army," Dabbs recalls, "but it didn't matter. I still came over and helped out in the tank and nobody asked who I worked for or cared. The thing was to do the job. That was just the way it was then."

In this spirit of informality and enthusiasm, the team began to create the techniques and procedures that would be used in all underwater space simulators. "We weren't spending much money if any at all," Schwinghamer says. "My guys just went out and found what they needed, checked with me on their idea, and then installed whatever it was. They were all eager to work on this thing. I had to remind a lot of them to go home at night. They were in that tank just about every weekend too. It was an exciting time."

While Huntsville was vigorously pursuing the idea on a volunteer, low-cost basis, managers at Houston's Manned Space Center were just starting to think about the possibilities of underwater space simulations. In the fall of 1966, astronaut Scott Carpenter donned a Gemini suit and descended into a swimming pool to demonstrate the feasibility of removing an S-IVB part. But the difference between Huntsville and Houston was that Houston approached the use of underwater space simulations in a more methodical manner, requesting NASA headquarters to fund a facility with full staffing by a contractor. Headquarters put Houston's tank on its wish list, but space program funding was tightening up. By the time Houston realized it wasn't going to get a new facility and decided to go with an existing small tank that had been used to practice splashdowns, Huntsville had forged ahead in neutral buoyancy techniques.

With Skylab in danger of being broiled by the sun, Marshall staff brainstormed rescue schemes, sketching out some on a blackboard (right). Once the rescuers had designed and cobbled together a "twin-pole sail" to cool the craft, Rusty Schweickart (left) and others entered the Neutral Buoyancy Simulator to practice deploying the device. After the rescue, Schweickart and Cooper practiced one of the EVAs originally planned for the Skylab program (opposite).

Marshall engineer Joe Dabbs (below) contributed to the early research by teaching Cooper's team how to scuba dive.

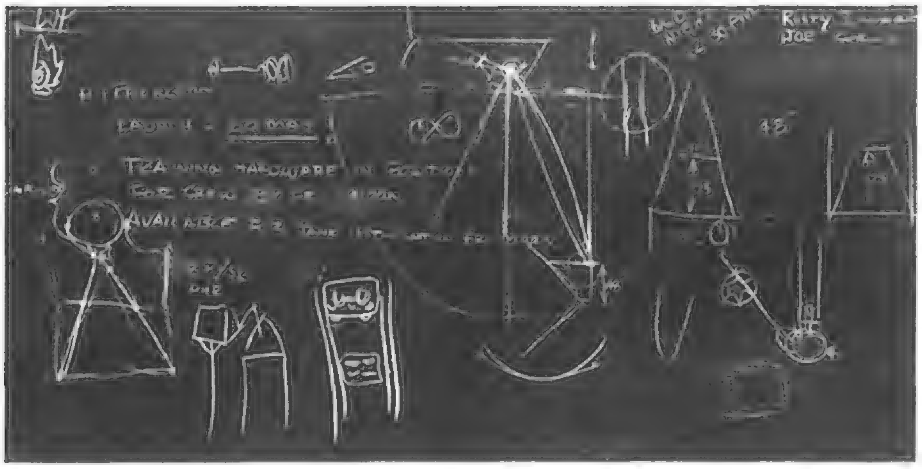
NASA's AAP Office was now ready to undertake some formal testing of underwater space simulation, and in February 1967 the office decided that for the tests it had in mind, Huntsville was the best center for the job. Houston was not only having problems getting a facility, it also lacked personnel with much experience in neutral buoyancy techniques. It was a quiet victory for Marshall, one that moved the Huntsville center into the arena of manned spaceflight.

Up to this point, all responsibility for human spaceflight had been given to the Houston center, and with the center's mentor, Lyndon B. Johnson, sitting in the White House, the monopoly seemed secure. But now that Marshall's neutral buoyancy simulations were challenging this arrangement, many in Huntsville were pleased. Their town was building the rockets that would take men to the moon, but it was "Houston" that was coming out of the mouths of the astronauts every time they spoke, and it was Houston the American people had started to think of when they thought of NASA. If all seemed serene at the top of the management chains of the two centers, underneath was a charged competition. And the most visible prize of that competition was the astronauts themselves.

Alan Bean was the first astronaut assigned to come up to Huntsville to try out Schwinghamer's tank. In 1967 Bean began a series of underwater tests using equipment essentially built from salvage. Schwinghamer remembers one memorable day when Bean was in the tank trying to take bolts out of a plate. He had managed to remove a few when suddenly a hole about the size of a silver dollar blew out from under his right armpit. Slowly, his suit began to collapse. Schwinghamer, who had been serving as one of Bean's safety divers, tried to plug the hole but got nowhere. He recalls: "I went to the surface and yelled at the guys to jack up the suit pressure as high as it would go to get him air, but in the meantime Al had calmly walked across the bottom of the tank and got to the ladder. Then he just climbed up and out. He wasn't mad or upset. Like the rest of us he just wanted to fix the suit and get on with the test. That's an attitude you can't beat."

Still, the Marshall team always worried that their work at the tank would be perceived as overstepping time-honored boundaries. "At first, we had an inferiority complex about what we were doing and we felt like we were always on the verge of being shut down," says Schwinghamer. "We always felt like somebody was looking over our shoulders just waiting for us to make a mistake, to say that we shouldn't be working with the astronauts. But after a while we realized we had become the experts in extravehicular activity. We had done it first here and we had done it in a big way."

Wernher von Braun maintained a fatherly interest in underwater training: in 1968 he managed to get Marshall a new, larger tank—the Neutral Buoyancy Simulator, which measured 40 feet deep by 75 feet across. He greased the way for this expenditure with a little creative accounting. The way such a structure was funded normally depended on whether the item was cat-



egorized as a tool or a facility; since the latter required Congress' approval, von Braun simply opted to call the new tank a tool. "We built the tank ourselves with just NASA personnel because there wasn't enough money to hire a contractor to do it," says Cooper. The tank was completed just two months after the materials were delivered, and at a cost of $219,000, well under budget.

The facility became an interesting study in job placement. "We hired the same guys who built it to work in it," Cooper says. "It didn't matter if they had been draftsmen or machinists or engineers. Everything was new so what counted most was enthusiasm."

The Apollo Applications Program gradually evolved into the Skylab program, the United States' first manned space station. The mission had changed since it was originally formulated: now the lab would be built on the ground and sent up unmanned, and a separate launch would send a crew up to operate it. In 1969 headquarters gave Huntsville the responsibility to design, develop, and build Skylab.

By the time the station was ready for launch, the Huntsville tank had completed five years of operations, and almost all of the astronauts had trained in it. Although Houston still had the job of training the Skylab crews, Charlie Cooper and astronaut Rusty Schweickart got the primary roles in training the first Skylab crew—Pete Conrad, Joe Kerwin, and Paul Weitz—in extravehicular activity.

On May 14, 1973, the Skylab module was launched aboard a Saturn V. But as soon as the lab had made it into orbit and begun to transmit data, ground controllers knew something was wrong. Not only would the solar panels not deploy, but the temperature inside the station was rising rapidly. A quick analysis revealed the likely scenario. The module had been tightly fitted with a shield for protection against micrometeoroids and other space debris. As the rocket reached an altitude of lower pressure, the relative pressure of the air between the shield and the module climbed. Finally, the pressure grew so high that the trapped air blew off a big piece of the tight-fitting shield. The shield in turn broke off one of the solar panel wings and jammed the other with debris.

The reason the temperature in the module was going up was that the shield, in addition to providing protection from space debris, had insulated the module from the sun's heat. Without this protection, the module's sensitive instruments were being broiled. NASA would have to either abandon the billion-dollar facility or train the lab's crew to fix it.

Rusty Schweickart had spent hours in the tank working out the requirements for the expected Skylab extravehicu-

lar activities, and clearly any repair was going to require additional EVA. "Houston told me to get up to Huntsville and get something organized," Schweickart recalls. Joining the astronaut was Skylab crew member Joe Kerwin. While ground controllers in Houston frantically turned Skylab away from the killing heat of the sun, Schweickart began to chalk ideas on a blackboard for devices that could save the mission.

Cooper remembers the crisis atmosphere of the room: "Whatever we came up with had to be ready in 10 days or less. The Skylab crew was going up on May 25. We just threw the thing open." Ideas were accepted from everyone, including machinists who came in from their workshops to see what was going on. Eventually, Schweickart came up with the idea of a sunshade, and the group began hammering out the details.

The team worked far into the night, trying all sorts of ideas. Finally Cooper joined Schweickart and Kerwin at the board to detail the procedures needed to deploy the suggested sunshade, which the rescuers named the twin-pole sail. They also had to devise a plan to break the jammed solar panel free.

On May 15, the day after the Skylab launch, Cooper was in the water in a Skylab spacesuit going through the motions of the procedures on the Skylab mockup. The next day Schweickart and Kerwin got in. By that evening Marshall machinists had fabricated the twin-pole sail and all of the ropes and pulleys that made it work. On May 17 a mockup of the command module, the Apollo capsule the crew would use to fly up to Skylab, arrived in Huntsville to be put into the tank. Things were happening at lightning speed.

Schweickart recalls the enthusiasm that swirled around the tank: "Some of the tank staff worked 72 hours straight at least, even though I tried to get them to take some time off. I was just as bad, on the phone all hours of the night, calling people all over the country ordering materials, reviewing specifications."

On May 21, after a series of various in-tank trials, Al Bean and astronaut Ed Gibson did a complete end-to-end test run employing the sail. As soon as they got out, staff divers plunged in, readying the tank for another test. Far into the night, Cooper stood in the command module forward hatch and worked to see if he could free the solar panel. He was scarcely out of the tank before Pete Conrad, the commander of the first Skylab crew, and Joe Kerwin got back in.

All the next day Conrad and Kerwin, outfitted with bulky Skylab suits, practiced putting up the sail and using the tools needed to remove the debris pinning the solar panel. Their recommendations for redesigning tools and refining procedures were recorded by Cooper and his group and tried out in the tank two days later. The results were phoned in as the Skylab crew prepared to go to Cape Kennedy in Florida.

On May 25, Conrad, Kerwin, and Weitz were launched. Once inside the Skylab module, the crew first installed a shade through an airlock, temporarily solving the heat problem. But with the solar panel stuck, not enough electricity would be generated to operate the station properly. While Conrad piloted the Apollo module around Skylab he described the damage, and based on that information Cooper and the tank staff plunged back into the water to devise the best way to free the panel. "We mocked up the piece holding the wing just like Pete described it and then worked on freeing it," Cooper recalls. "Rusty talked the results to the crew. When I got out of the water I stayed in my suit, ready to go back in if I was needed to test some idea."

It was, perhaps, the Neutral Buoyancy Simulator's finest hour. Following the tank's recommended procedures, Conrad and Kerwin went outside Skylab, set up their gear, and levered the solar panel wing loose. An explosion of cheers erupted among the crew of Huntsville's tank.

Because the temporary shade seemed to be keeping the lab's temperature down, and because the crew was worn out from the repair work, mission control decided to leave the erection of the twin-pole sail to the second Skylab crew. After extensive training in the tank, those astronauts—Owen Garriott, Jack Lousma, and Alan Bean—went up on July 28. Ten days later, they successfully erected the twin-pole sail. "Everything we practiced in the tank at Huntsville proved easy in space," recalls Garriott.

Accolades for the tank were to be short-lived. When the third crew returned to Earth on February 8, 1974, the Skylab era came to an end, and for the time being, the United States pulled back from manned space efforts. No matter how well it had accomplished its mission, the tank, like the rest of NASA, would be affected by this retreat. And when the changes came, they came suddenly.

As part of an overall reorganization dictated from headquarters in 1976, the tank staff was decimated. Even though they had helped to build the structure with their own hands and had developed and refined the techniques of EVA, many workers were out of a job or were sent back to the old jobs they had had before their tank assignments. "It was a tough time," Cooper remembers. "I'm convinced it killed one of our guys. At the tank, he was a test director on a first-name basis with the astronauts, and all of a sudden he was back at a drawing board again. It ate him up inside. They said it was a heart attack that killed him. Heartbreak was more like it."

In 1980 Johnson Space Center in Houston opened the Weight-

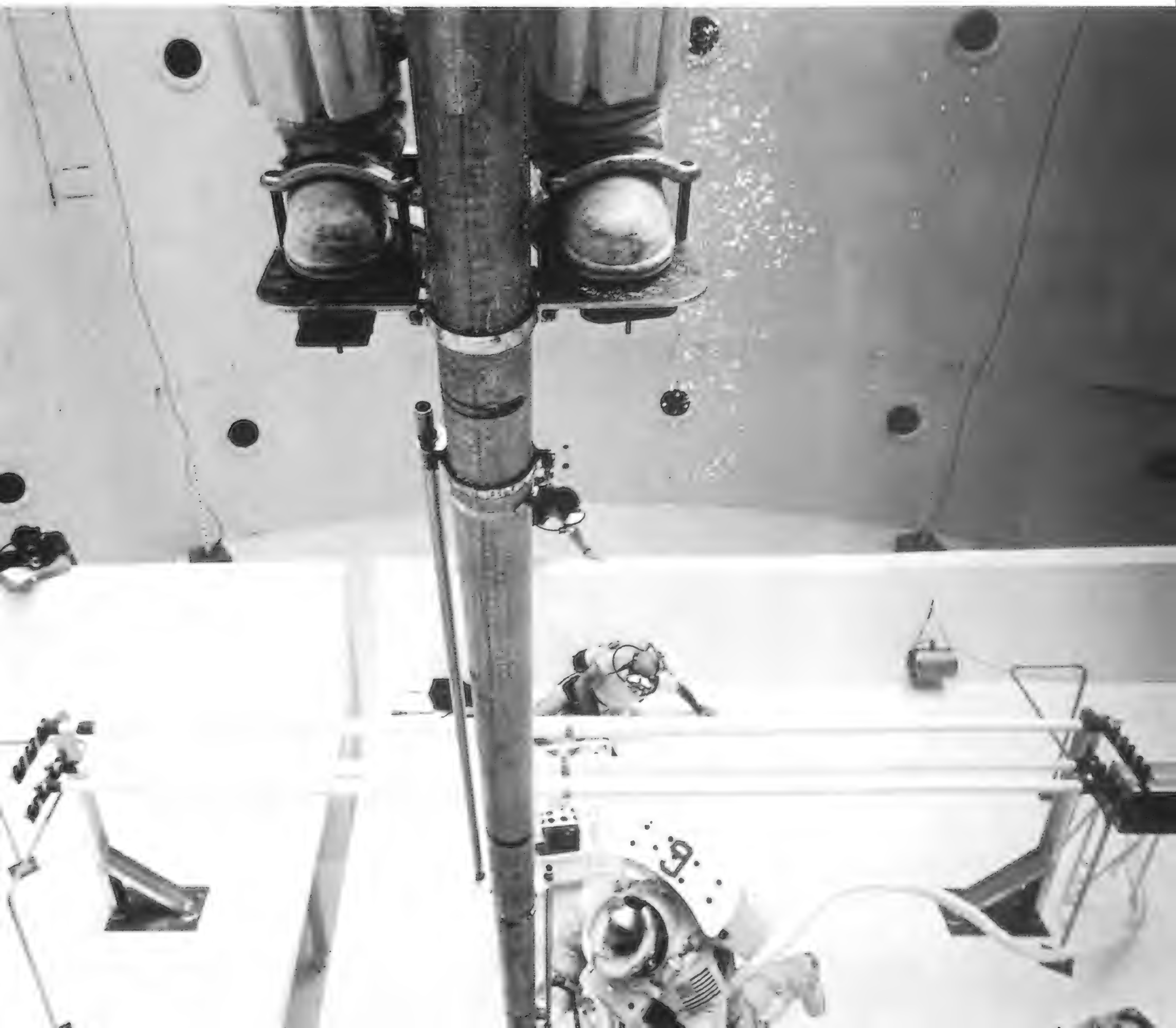
DENNIS KEIM, NASA

less Environment Training Facility, a tank much smaller than Marshall's. Houston became the focal point for underwater astronaut training. But even though all EVA training was supposed to go to the WETF, Charlie Cooper kept working to keep the Marshall tank busy during the 1980s. One of the jobs he snagged was work on the Hubble Space Telescope, because only the tank at Huntsville was big enough to hold a mockup of both the Hubble and a shuttle cargo bay. The Huntsville tank is now being used to fine-tune the procedures needed to correct the Hubble's nearsightedness. Twenty years after its first rescue, Huntsville's tank may once again save a major NASA mission.

In 1987 Cooper decided he needed a change. "It just wasn't the same anymore," he says. "All the old hands were gone. We weren't doing much that was new. It was time to let the next bunch build on what we had done." So he moved on, applying his brand of practical engineering to the environmental control and life support systems for space station Freedom.

When asked what he recalls best about that period, Cooper says, "I remember mostly how much fun it all was.... We were all having fun but at the same time we knew what we were doing was important. We didn't do it for the money, that's for sure. We did it because the people over us, Schwinghamer and von Braun and the rest, let us do it. That's what I miss, if anything. The feeling that we could do anything as long as it was good for the program."

Water tanks don't replicate the weightlessness of space perfectly, but they are realistic enough simulators to prepare astronauts for most complex missions involving spacewalks.



It's Time to Go Supersonic

Daniel S. Goldin,
NASA
Administrator

We need to develop the technology for a passenger airplane that will fly 2.5 times the speed of sound. And we need to do it now.

Recent massive layoffs in this country's aerospace industry tell a story that no American should want to hear. U.S. aviation is in a nose dive. Yet right now we have a perfect opportunity to seize the controls and recover.

At its height, the U.S. aeronautics industry provided more than a million jobs and generated $100 billion in annual sales and tens of billions in exports. In 1969 we were selling more than 90 percent of the world's transport aircraft.

And then we rested.

First, we let Europe score a technological triumph with the Concorde supersonic airliner, however noisy, polluting, and uneconomical it may be. The experience Europe gained building it paved the way for the creation of the Airbus consortium, which has grabbed an impressive share of the airliner market with a full line of advanced commercial aircraft.

America walked away from other markets that we once dominated. For example, new made-in-the-U.S.A. short-haul commuter aircraft have almost disappeared from the skies.

The bottom line: our share of the world market has dropped to 67 percent and foreign competition is getting even stronger.

So how do we climb back to the top? You'll get as many answers as there are experts, but some priorities are clear. We need to revolutionize air traffic control technology and get it into the next generation of subsonic aircraft. We need to find ways to make those aircraft safer, quieter, and more fuel-efficient.

And most of all, we need to develop the technology for an environmentally friendly, economically successful high-speed civil transport, a passenger airplane that would fly 2.5 times the speed of sound. And we need to do it *now*.

No single program that NASA and U.S. industry can undertake will have such an impact on our nation's efforts to regain its share of the aviation market, produce manufacturing jobs, and reassume the leading edge in aeronautics. Nor will anything else be so technically difficult—but I'm convinced we can and should do it before somebody else does first.

Thanks to a rise in the political, economic, and cultural integration of the globe, long-haul over-water air travel will increase remarkably by early in the next century. Even conservative estimates say that 300,000 passengers will travel each day by the year 2000 and 600,000 by 2015. Studies by Boeing and McDonnell Douglas show that a large part of that market, at least 500 and as many as 1,000 airplanes, can be captured by a new high-speed civil transport. The reason is obvious. Imagine spending two days on a trans-Pacific business trip instead of a whole week! A new airliner that flew at Mach 2.5 could travel from San Francisco to Tokyo in 4.3 hours or Los Angeles to Sydney in 7.3 hours (with a one-hour stop in Honolulu). The technology needed to make the aircraft successful would also result in fares roughly equivalent to those for subsonic airliners; even so, the studies suggest that many fliers would be willing to pay a little more if they could spend less time traveling from point to point.

There are some catches, of course. A new supersonic passenger airplane must not adversely affect the environment, and it will have to be as quiet as today's subsonic jets. Industry will decide to build the airplane only if it has the range, passenger capacity, and fuel efficiency to make routine airliner operation possible. Airlines will fly it only if they can do so at a profit. Developing the technology to overcome these challenges is a risky business, and U.S. industry isn't going to do it alone when it already takes companies 10 to 20 years to get back their investments on far less dramatic improvements.

NASA's business is to share that risk. We're already conducting some of the vital atmospheric and technological research the private sector needs to review before it can commit to developing a high-speed airliner—and we're planning to do more. Even at this early stage, the results are extremely promising.

If the United States doesn't build the next supersonic transport, somebody else will.

NASA is working closely with an international group of leading atmospheric scientists to gauge the potential effects of a high-speed fleet. We are plugging in the best data available from research aircraft, satellites, and ground experiments to produce the most accurate models possible. There is much work still to be done, but it looks like there are regions in the stratosphere where aircraft equipped with low-emission engines can operate without noticeable impact on the atmosphere.

The key is to create technology for engines that will produce nitrogen oxide (NOx), an ozone-depleting compound, at such low levels that it will not harm the ozone layer. Here again, we've had outstanding success. Laboratory tests of low-NOx combustion chamber concepts show that emissions can be cut by 90 percent.

We're also making progress on the other environmental and technical barriers to high-speed civil transport development. NASA has evaluated technologies that promise to reduce airport noise by up to 15 percent compared with the levels produced by the Concorde. We're also researching advanced high-lift devices that would let a future supersonic airliner climb out and land more efficiently at lower engine power levels, which make less noise.

Sonic boom levels also seem to be yielding to advanced engineering. Our computer simulations and wind tunnel tests show that careful shaping of a high-speed transport's fuselage and wings may reduce sonic boom levels during the over-water cruise part of the craft's flight path. (The airplane would fly subsonically over land.)

The huge probable market demand and the technical successes to date indicate there's a good chance aircraft manufacturers should be ready to build a high-speed civil transport early in the 21st century. If we forge ahead at a rapid pace, the first aircraft could get certificated as early as 2005.

Critics will ask why we should spend tax dollars to develop technology for an airplane that will be used by only a privileged few. "Let's axe that part of NASA's budget," they clamor; "it will be that much more chopped off the deficit."

They're off base on several counts. First, the technology we're researching today isn't geared toward an airliner just for the rich and famous. NASA's high-speed research program, and any design that our work may eventually spawn, will be successful only if the airplane's fares approach those of future subsonic jetliners. That's our goal and it's realistic.

The second part bothers me even more, because I truly feel reducing or eliminating NASA's efforts in the high-speed arena is just the opposite of what's required for long-term deficit cutting. Experts say global sales of commercial transports could approach $1 trillion by 2015. If we close our eyes to this enormous potential market, our aeronautics industry—including the subsonic area, where we still enjoy some advantage—will continue its descent, possibly going the way of the U.S. steel and textile industries.

Reducing NASA's efforts in the high-speed arena is the opposite of what's required for long-term deficit cutting.

But if we are the first nation to develop the advanced technology in materials, aerodynamics, propulsion, and flight deck systems that a practical high-speed civil transport requires, those advances will stimulate many other applications. We will certainly use them to greatly improve all classes of U.S. aircraft, both civil and military. A successful supersonic airliner alone could boost our total market share to nearly 80 percent and create as many as 140,000 new jobs.

Opponents of supersonic research look at the technological risk and cry, "What if we fail? How can we explain all that money down the drain?" I look at this unprecedented opportunity and say, "What about the risk of *not* trying?" If we don't try, we've already failed. How will we explain America's continued slide in aeronautics and the loss of more billions of dollars and hundreds of thousands of jobs?

America can develop the technology for a new supersonic airliner, or somebody else can do it and reap the benefits. To me, that's an easy choice for the country to make—and the time to make it is now.

Story and photographs by David Doubilet

SUNKEN TREASURES

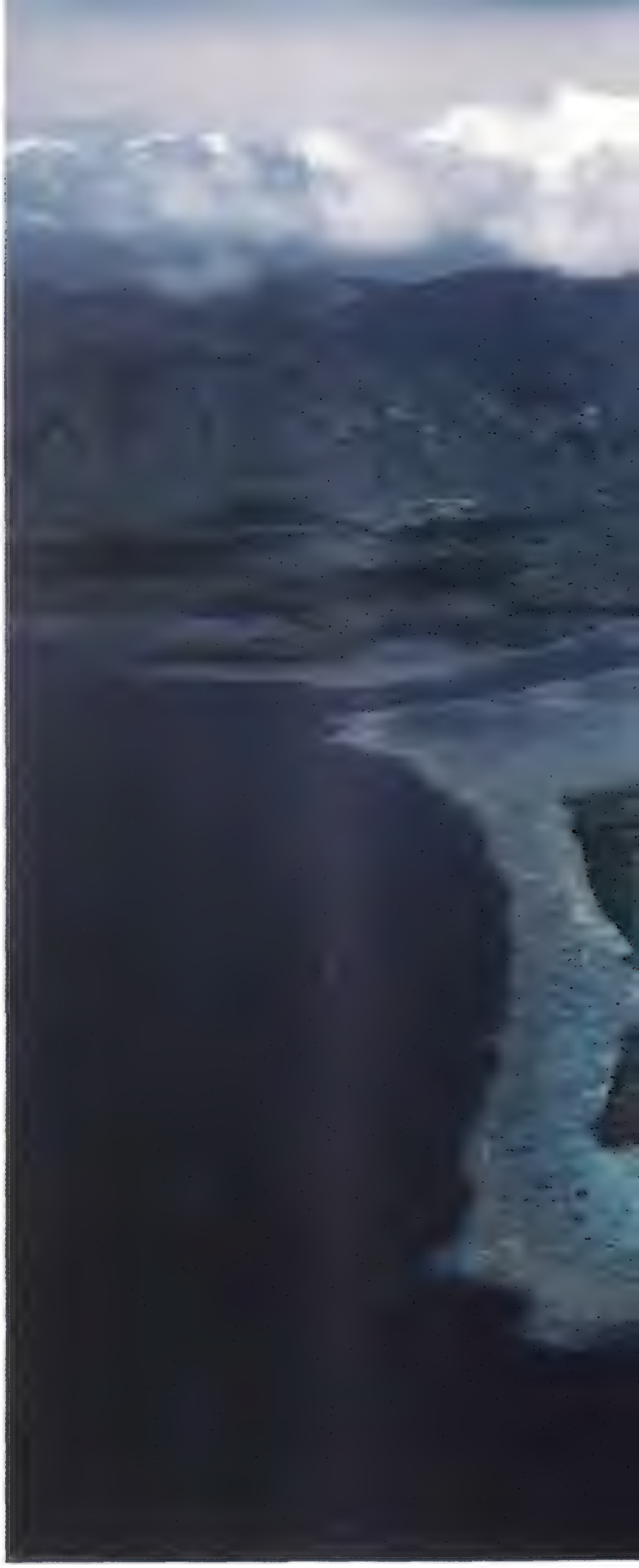
In the depths of the Pacific, an underwater photographer captures a ghostly gallery of warbirds.

I've loved airplanes since I was a kid. I'm still crazy about them. However, as a professional underwater photographer I spend most of my time in the sea, not in the sky. Occasionally, though, I've had the opportunity to combine my profession with my love of aircraft. In the last five years, I've had several assignments across the southwest Pacific, near Papua New Guinea

A barrel sponge has taken up residence near the propeller of a Japanese Zero shot down during World War II off the coast of Rabaul (above). Situated on the northeast tip of New Britain, Papua New Guinea, Rabaul was the site of a Japanese air and naval base. The Zero's cockpit (opposite), teeming with a school of silversides, has become fertile ground for coralline algae and sponges.

A tiny red squirrel fish checks out the coral-encrusted cockpit of a P-38 at the bottom of Milne Bay (below). The lush, mountainous land surrounding Milne Bay (right), located at the southeastern tip of Papua New Guinea, has changed little since the war.

A Japanese Kawanishi flying boat entombed in Simpson Harbor near Rabaul's main airstrip has become a popular spearfishing site for the local schoolchildren (below).



Perhaps the prettiest warbird wreck in the entire southwest Pacific is a "Pete" Mitsubishi scout biplane, which rests on its single float at the foot of a reef near Rabaul (right). Nearly smothered with soft coral and sponges, the Pete attracts a variety of fish.

and the Solomon Islands. The seas surrounding these islands hold the richest coral growth in the world; some fifty years ago they were also the site of the great battles of the Pacific war, an endless series of duels between aircraft and ships. Not surprisingly, hundreds of warbirds were lost at sea.

When an airplane falls out of the sky and into the water, it suddenly changes from a noisy weapon of war to a resident in a silent world. After it slowly sinks to the bottom of the ocean, it becomes a living sculpture. The sea simply adopts it as one of its own, covering and softening its edges with marine life the way an oyster coats a pearl. There is

A hazard for Pacific island divers, the venomous scorpion fish sports dorsal spines that emit poison when touched (below).

On the night of July 11, 1943, the B-17 Black Jack *(above) bombed the Japanese base at Rabaul. During the return trip to home base, bad weather forced pilot Ralph DeLoach to belly in near the beach of Boga Boga, Papua New Guinea. Rescued by the villagers of Boga Boga, the entire crew survived.*

great beauty in the sight of an old fighter encrusted with soft coral and framed by sponges, its cockpit filled with schooling fish. It gives me a stronger sense of time and space, distance and history, than any other kind of subject I've ever photographed.

But however much the sea tries to change it, the warbird remains an aircraft—just in a very different environment from the one for which it was designed. Yet if an airplane happens to be in the path of a current, you can feel the water speed up as it passes over the wing, just as air would do. And unlike

photographing an airplane on land, in the sea I can move effortlessly around it, finding the best angle for my picture.

When I photograph these underwater sculptures I feel like a gem cutter finding the perfect diamond, for like precious gems, these wrecks are rare. Although World War II aircraft were built heavy and sturdy enough to withstand machine gun fire, when these airplanes hit the water they often broke apart like eggshells. And even when aircraft did remain intact, they often landed upside down, destroying the illusion of flying in the sea.

Adding to the scarcity of suitable wrecks to photograph is the depth of the water around the southwest Pacific islands. In some places, only 100 yards from shore the water is 1,000 feet deep. There may be some spectacular airplane wrecks at 3,000 feet, but they are beyond the range of safe diving. Then, too, the water around these islands is not always clear. Many of the islands are mountainous or have active volcanoes, and the runoff they produce makes the surrounding water very dirty. I have photographed aircraft in cloudy water, but of course you can only capture one piece at a time. If you can, however, find intact, upright airplanes located in clear, shallow water, then the sea becomes a gallery—an endless, blue-walled gallery.

A Navy SNJ painted as an Air Force AT-6 flies past Kaena Point in Oahu, Hawaii (below). The setting is similar to the one Japanese pilots observed when they returned to their carriers after raiding Pearl Harbor. Today a Japanese "Kate" bomber, a type of aircraft used in the raid, lies just off the northern tip of New Ireland, Papua New Guinea (opposite).

ASTRONOMY'S
MOST WANTED

FIFTH IN A SERIES

THE GREAT GAMMA RAY MYSTERY

Something out there is releasing unimaginably intense bursts of radiation. What is causing them and where are they coming from?

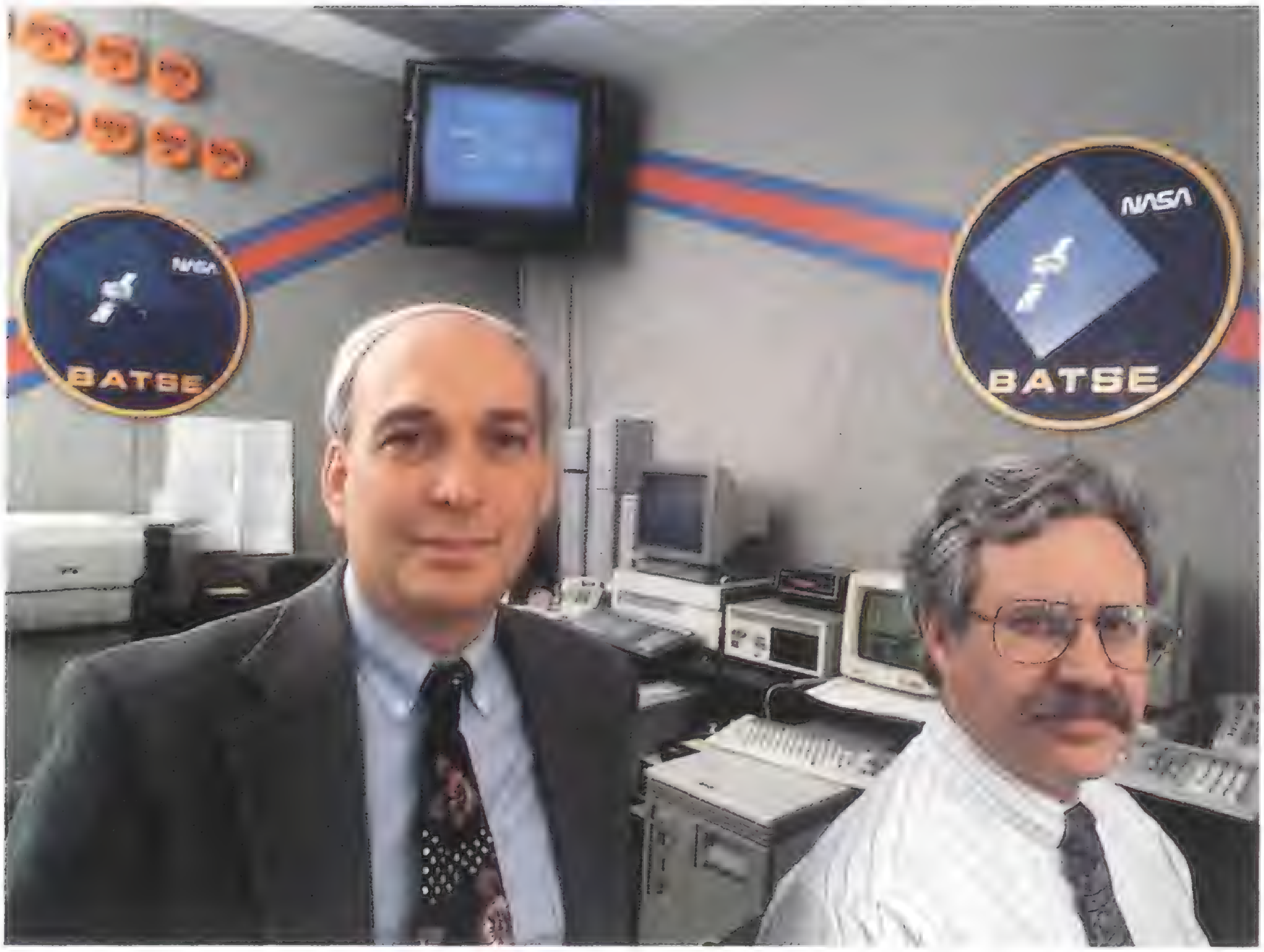
by Linda Shiner

Jerry Fishman likes to imagine what night would be like if human eyes could detect high-energy radiation. "If our eyes were sensitive to X-rays and gamma rays, the sky would look real marvelous," he says. "We'd see sources coming and going, and flickering and flashing." Fishman pauses to let the scene sink in: at the very highest energy range of the electromagnetic spectrum—gamma rays—every day is the Fourth of July. If only astronomers could see with their own eyes these intense flashes—so bright that for a few seconds they overpower everything else in the sky—maybe they could figure out what creates them.

Fishman runs the gamma ray astronomy branch at NASA's Marshall Space Flight Center in Huntsville, Alabama, and he is not ashamed to tell you, in a gentle Missouri accent and with a steady earnest gaze, that he has no idea what's causing the fireworks that the Compton Gamma Ray Observatory is detecting from its orbit 250 miles above Earth. Each day, an average of once and sometimes as many as five times, a burst of very high energy photons, lasting anywhere from milliseconds to a few minutes, rains on the GRO's detectors. Whatever these phenomena are, they are unbelievably violent. Some scientists estimate that the amount of energy released in the few seconds of a burst exceeds the total energy released by the sun for a thousand years.

Launched by NASA in April 1991, the 17-ton GRO carries four huge instruments designed to study objects in the universe that emit gamma rays, radiation ten thousand to ten billion times more energetic than visible light. The GRO's targets include supernovae and their remnants, active galactic nuclei, quasars billions of light-years distant, and high-energy objects concentrated in the plane of the Milky Way such as neutron stars. Fishman's device on the GRO is the Burst and Transient Source Experiment, or BATSE. An assembly of eight detectors positioned on the corners of the satellite, BATSE is capable of watching all of the sky not blocked by Earth. From its watch, BATSE has handed astronomers plenty of something they don't usually get: radiation they can detect but can't explain. The gamma ray bursts detected by

ART BY ANDREAS NOTTEBOHM



ALAN S. WEINER

Jerry Fishman (left) and his colleague Chip Meegan have spent nearly 20 years trying to identify the source of gamma ray bursts.

BATSE don't come from any of the sources the other instruments study. In fact, of the 609 bursts BATSE has recorded in the two years since launch, not one has come from any known star or galaxy or quasi-stellar source. Not one has come from the same spot twice. The bursts simply appear, then vanish.

"I hate to use the word 'spectacular,' " Fishman says, "but something new's gonna come of this. Something we haven't seen before. It could turn out to be something explainable by, uh, I just don't know," he says, shaking his head and smiling. He seems pleased that here at the end of the 20th century nature can still toss scientists so difficult a puzzle—one unsolved since 1967, when the first gamma ray burst was detected (see "The Nuke Police," opposite).

Every day BATSE transmits its observational data from the past 24 hours. Every day Fishman and a team of about 15 astrophysicists at Marshall's space science laboratory pull the data apart. "You never know where the clue's gonna come from," says Chip Meegan, a friendly, witty scientist who oversees the data analysis. "We dig as much out of these bursts as we can." Meegan has worked with Fishman on gamma ray burst detectors for almost 20 years. They spent 13 of those years designing, building, and flying BATSE, and there were times, Fishman says, when they both wondered if they were doing the right thing by spending so much of their careers on this one experiment instead of publishing as many papers as possible and advancing their own knowledge. But Meegan and Fishman stuck it out. Now their results are published not only in prestigious scientific journals but also in such mainstream publications as the *Washington Post* and the *New York Times*. The likelihood that gamma ray bursts will reveal a previously unknown astronomical phenomenon has made them world news.

Marshall's space science lab is a converted weapons factory from the center's early years as the Redstone Arsenal; its fluorescent-lit halls and offices are strictly government issue. In a tight wing of small offices crowded with computers and temporary office dividers—referred to by the BATSE team as the Bat Cave—scientists and grad students pursue the sources of gamma ray bursts with the single-mindedness of detectives. They proceed in two directions at once: They study the bursts' fingerprints and they zero in on burst locations so other detectives can look for accomplices.

The fingerprints BATSE takes of gamma ray bursts are

their temporal profiles, displayed in graphs that look a little like tracings produced by a lie detector detecting some whoppers. When a lot of photons arrive at once, there are sharp peaks in the graph.

In the Bat Cave the astronomers subject burst temporal profiles to mathematical operations that a non-scientist would find terrifying. They stretch, compress, and turn the graphs inside out in the hope of discovering patterns in the seemingly random flux of photons.

Chryssa Kouveliotou, an astrophysicist at Marshall, has been searching for similarities among the highly varied burst profiles in order to develop a taxonomy of the phenomenon. "That is one of my favorites," she says, describing a burst with eight peaks and a lot of little jagged dips and hills. She traces slowly over another graph with her finger, describing its "structure" as a botanist might speak of an exotic plant.

The energy released by a burst can exceed the total energy released by the sun for a thousand years.

Perhaps more frustrating to astronomers than the chaotic nature of the bursts is that they give few indications of the distances they are traveling. Is a dim burst coming from a weak source close to Earth or is a dim burst coming from an unthinkably strong source billions of light-years away? How can astronomers tell the difference? Some of the most promising research is being undertaken by

The Nuke Police

The satellites that first detected a gamma ray burst were looking for something they never saw: evidence of a Soviet thermonuclear test conducted beyond the Earth's atmosphere.

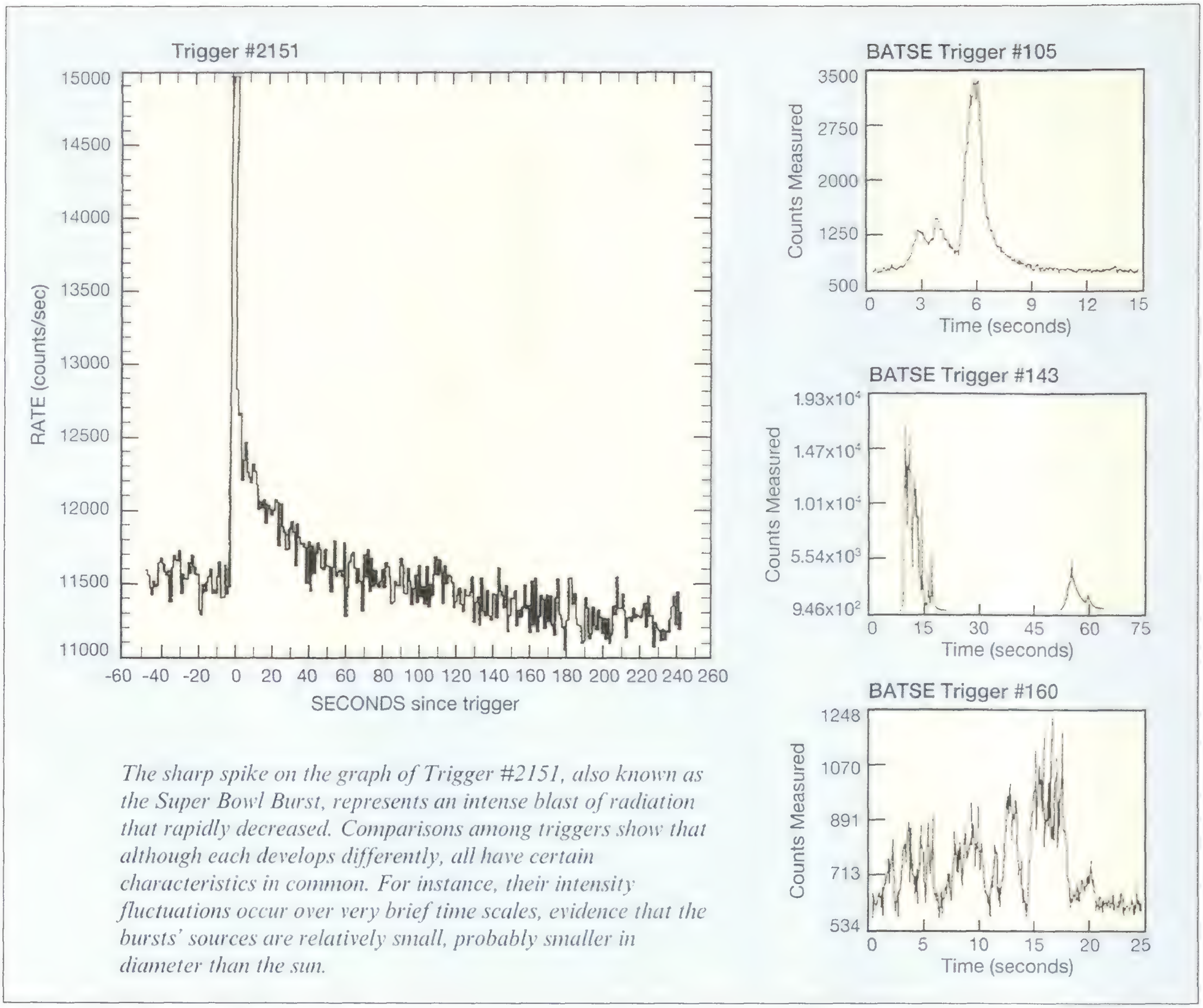
One of the first actions of the Pentagon's new Advanced Research Projects Agency, created in 1958, was the sponsorship of secret monitoring systems that could tell if the Soviets were cheating once a test ban did go into effect. When ARPA wanted a device that could identify the signature of a nuclear bomb in space, it turned to the place that knew best what that would look like: Los Alamos National Laboratory in New Mexico.

The Vela Nuclear Test Detection Satellites were a partially classified system of four orbiting nuke police equipped with X-ray, neutron, gamma ray, and charged particle detectors. They were launched in pairs from Cape Canaveral beginning in 1963. Ray Klebesadel, an electrical engineering graduate of the University of Wisconsin who designed the gamma ray detectors, says they were included because "back in the '60s there was some concern that other nations had the capability of detonating a nuclear device behind another planet or a deployed shield." The X-ray detectors would have caught an unshielded explosion but may have missed a shielded one. Gamma rays, however, would have been emitted by the debris cloud, which expands at 1,200 to 3,000 miles a second and grows rapidly bigger than any hiding place.

In 1969, Klebesadel and colleague Roy Olson were scanning archival data from the Vela system to prove a point. They were trying to establish that their detectors couldn't be fooled by some natural phenomenon into believing they'd seen a bomb explode. Recalls Klebesadel: "We had always claimed that any false responses in a single satellite could be rejected by virtue of the fact that only one satellite would be affected and we would not see simultaneous data on more than one." What they found, however, were two identical records of a single event that had triggered the detectors in July 1967. A closer look at the archive showed that three of the four satellites had seen the same event.

Klebesadel says he and Olson didn't think for a second they were seeing the traces of a nuclear explosion. "It was clear that this was a natural event," says Klebesadel. "It was quite intense and had a structure that was quite distinctive—a short pulse of .125 seconds' duration followed by a second pulse of two seconds' duration. And it was clear that it was something quite far from Earth because the intensities were nearly the same as recorded by the two systems, which were pretty well separated." No, Klebesadel and Olson weren't worried. Even though they saw 10 more events in the archive, they were still confident that none had been a nuclear explosion. But now they had enough data to notice a property that unnerved them and continues to perplex astrophysicists today: the tremendous variety among the temporal structures of gamma ray bursts.

With such a broad range of structures to deal with, Klebesadel realized that a burst could someday mimic the signature of a nuclear explosion. But the greatest significance of his discovery is that it gave astronomers one of their first visions of chaos in what they had believed to be a steady, predictable universe.



The sharp spike on the graph of Trigger #2151, also known as the Super Bowl Burst, represents an intense blast of radiation that rapidly decreased. Comparisons among triggers show that although each develops differently, all have certain characteristics in common. For instance, their intensity fluctuations occur over very brief time scales, evidence that the bursts' sources are relatively small, probably smaller in diameter than the sun.

Jay Norris, an astrophysicist at NASA's Goddard Space Flight Center who studies the radiation signatures of both bright and dim events. After running 150 burst profiles through a heavy-duty mathematical technique called "wavelet transforms," Norris has discovered that the temporal structures of dim bursts are twice as elongated as those observed in bright bursts. He believes that he is seeing the characteristic stretching, or dilating in time, that would place the burst sources about half the distance between Earth and the population of quasars, the most distant objects ever detected.

What would also help determine the distances that bursts are traveling is the chance to study a very bright one. The brighter the burst—the more photons it sends—the more information scientists have to work with. That is why Fishman and Meegan, even before the launch of the GRO, instructed operators at Goddard, who are in real-time contact with the satellite 24 hours a day, to notify them immediately should the detectors start counting very high rates.

On January 31, 1993—Super Bowl Sunday—the big one came: the brightest burst BATSE has ever detected. Chryssa Kouveliotou, who happened to be at the lab, saw it

first. She alerted a GRO team working with another instrument, COMPTEL. That team also spotted the burst.

Jerry Fishman and the COMPTEL scientists notified the International Astronomical Union, which sent a message via electronic mail to observatories worldwide alerting them of a critical object to view. In the meantime, Fishman tried to reach astronomers he knew would be able to look in the burst's direction. "I got on my computer at home and through a modem contacted an astronomer in Chile and in Europe," Fishman says, "and I told them, 'This is the one we've been waiting for. It's strong and we got it real soon. And you guys better look at it if you can.' "

The day after the Super Bowl, Brad Schaefer was at the Cerro Tololo Observatory in the Andes mountains near La Serena, Chile, preparing to start an observational run on five calculated locations or "error boxes" where gamma ray bursts had been detected. While he waited for the moon to set, Schaefer got a message from the Goddard center giving an approximate location of the Super Bowl Burst. Thirty-five hours after the burst had triggered the BATSE instrument, Schaefer, using an optical telescope, produced a photograph of the portion of the sky where it had occurred. (Had Jerry Fishman's E-mail not been routed incorrectly, Schaefer might have broken the BATSE record, which is about 24 hours.) Schaefer immediately scanned the plate for something out of the ordinary. Then he compared his plate with one of the same region from the Palomar Sky Survey, a photographic catalog of astronomical objects that covers much of the sky. The stars that appeared on the new plate were the same ones that appeared on the Palomar plate. Nothing was new, nothing different, nothing unusual.

Back at Goddard, Schaefer, an expressive, fastidious man of enormous energy, admits to being disappointed, although he has come to expect disappointments in his 12-year quest for optical clues to the mystery of gamma ray bursts. Until the launch of GRO, Schaefer had concentrated more on finding counterparts or echoes of gamma ray bursts than on analyzing the bursts themselves. "Haven't found anything yet," he says. "And it's kind of like I've dedicated a decade of my life to trying to find these dumb things in optical, infrared, radio—you name it. And there's nothing there." On a shelf behind him are perhaps two dozen blue cloth-covered loose-leaf binders, all marked on the spines in an identical hand "γ-ray bursts."

"We know that the gamma ray burst has to be somewhere in there," Schaefer goes on. "They might be invisible, they might be bright, they might be who knows what!" he shouts. "We know they're in that error box somewhere there. The question is what's in that error box." Schaefer finishes his statement with a hushed, amazed tone, as if he's coaxing a child to guess what's buried in a sandbox. Many of his sentences sound as though he should finish them with "boys and girls."

"There are a lot of stars and how do you know which one of those stars is the counterpart? *Eeeeyeheh!* You don't!" Schaefer continues. "Because we don't know what a gamma ray burster is. We haven't the faintest idea. So we don't real-

ALAN S. WEINER

Every day at 11:00 a.m. the BATSE team gathers for a lively discussion of the instrument's latest data.

ly know what we're looking for."

Although the gamma ray burster itself remains hidden and no optical flash has been convincingly associated with a gamma ray burst in the 20 years they've been studied, astronomers cling to the belief that some of the energy from the explosion will appear in the optical spectrum. Their faith in optical echoes is anchored in their knowledge of how much hydrogen is in the universe.

Diffuse hydrogen gas, denser in some areas than in others, is present in some small concentration practically everywhere. The wavefront of gamma rays from the source of an explosion would flash-ionize whatever hydrogen is in the neighborhood. Eventually the electrons that were knocked free in that process would recombine with the hydrogen ions, and the recombination would produce light. Thirty-five hours after the Super Bowl Burst, that is what Schaefer was hoping to see. "We really don't know what the time scale of [the ionization and recombination] is," he says. "If the medium is relatively dense, the time scale could be fairly fast, like a day, so that's why we're trying to push as close as we can."

Obviously, the process of slewing a telescope toward the bursts can be streamlined a little from the system of phone calls, faxes, and E-mail that finally got word to Schaefer about the Super Bowl Burst. Scott Barthelmy, Schaefer's office mate at Goddard, has nearly finished building a computer-automated telescope that will push optical observations to within a few seconds of a BATSE trigger. Soft-spoken, low-key Barthelmy the instrumentalist seems to be the alter ego of extroverted Schaefer the observer. "It's hard to believe that you could take a zillion times the world's nuclear weapons supply and blow it up in a couple of seconds and not produce a few optical bursts," Barthelmy says dryly.

RICHARD NOWITZ

Bohdan Paczynski believes that gamma ray bursts may arise from the collision of neutron stars in extremely distant galaxies.

"You gotta be an optimist in this field, I keep tellin' myself," says Schaefer, who is going to Kitt Peak Observatory in Arizona this month to search BATSE error boxes located in the northern sky. "We just keep looking and looking and looking. Gamma ray data hasn't led us anywhere. It's led us to this horrible impasse where we haven't the faintest idea what's going on. And so I would make the claim, and"—here Schaefer feigns sobbing—"I'VE BET A LARGE FRACTION OF MY PROFESSIONAL LIFE ON IT, that the way we can solve gamma ray bursts is—basically the whole community agrees on this, if you can do it, and that's a big *if*—if you can find one, can find one confident counterpart—JU-U-U-ST ONE," Schaefer squeezes out the two words with

tremendous effort, "all of the sudden you'll know what it is because you can then sit there and stare at it."

Until recently, most astrophysicists believed that the object they'd see if they could stare at the location of a gamma ray burst would be a neutron star, the small, incredibly dense body that remains after a star has undergone a violent supernova explosion. Neutron stars, which are much smaller than the sun, were believed to be likely sources because the rapid flickering noticed in burst profiles suggests that the sources are small. In addition, neutron stars in the Milky Way had been pinpointed as the sources of regularly occurring gamma ray pulses. It seemed likely that they were producing gamma ray bursts as well. But in October 1991, BATSE scientists announced that the distribution of the bursts so far detected indicates that they are not within the plane of the Milky Way, where galactic neutron stars are concentrated. It is still possible that small, dense sources like neutron stars or black holes are responsible for gamma ray bursts, but if so, the BATSE data suggests that they are very, very far away.

"We don't know what a gamma ray burster is. We haven't the faintest idea."

"When the bursts [detected by BATSE] started coming, I think Fishman realized it first," says Chip Meegan in his small, windowless office at Marshall's space science laboratory. "All of a sudden Jerry said, 'There's somethin' funny here.' I think after maybe only a dozen bursts. But I found it very hard to believe."

Meegan, like most gamma ray astronomers, expected most of the weak burst sources to lie in the plane of the galaxy, the glowing band of stars that gave the Milky Way its name. If a population of objects is located within a galaxy, it is reasonable to expect to find the population where most of the galaxy's other objects are located. But the bursts that BATSE saw do not align with the galactic plane. There are as many outside, above, or below it as there are in it. The bursts are "isotropic," coming from here and there, everywhere evenly in the sky, similar to other objects surrounding the Milky Way, such as the most distant galaxies and quasars. These objects are so far away astronomers refer to their distance as "cosmological."

"[I was afraid that] maybe for some reason we were sampling out of the galactic plane," says Meegan, "[that] we were more sensitive to bursts out that way. Obviously a long shot. That shows, I think, how much I resisted."

"We wanted to make damn sure," says Fishman. They waited until they had 117 bursts. Then Fishman announced the startling observation that the distribution of the burst population did not resemble the distribution of stars in the Milky Way. "That's the striking thing," says Meegan, dropping his voice a little, "is how perfectly random they are."

Because Earth appears to be at the center of the burst distribution, astronomers know they can be coming from only three neighborhoods: an outer shell of the solar system, an unexpectedly extended galactic halo, or the universe as a whole.

There was probably no scientist in the world more delighted with Fishman's announcement than Princeton University's Bohdan Paczynski. In 1986 Paczynski published what is now considered a classic paper in the field, which proposed that the phenomenal energy of gamma ray bursts could be the result of neutron stars colliding in extremely distant galaxies. He was the first and for many years the only scientist in the United States to assert that the bursts could be coming from cosmological distances. This was not a comfortable position.

"I give Bohdan a lot of credit," says Fishman. "When the gamma ray conferences were held at Los Alamos, he used to take an amazing amount of guff about his theory. I used to feel sorry for him."

Paczynski is good-natured about the conferences. "I remember a conference and I was proposing what could cause these bursts," he says in a heavy Polish accent, "like merging

neutron stars, neutron stars disrupted by stellar-mass black holes…and I'd pause after each one of these statements, and there would be just tremendous laughter, people saying, 'He must be joking.' " This makes Paczynski himself laugh, bright eyes twinkling behind square tortoiseshell glasses. His cropped brown hair and animated conversation give him a boyish quality—the smartest kid in the class.

Emission mechanisms that powerful would require new particles and new physics.

Most of the scientists who resisted Paczynski's theories before BATSE's discovery did so because of the forbidding amount of energy the events at that distance would have to be generating. "The difference between whether they're local neutron stars or cosmological events is the difference in brightness between a flashlight and a nuclear weapon explosion," says Ed Fenimore, an astrophysicist at Los Alamos National Laboratory. "If they're at cosmological distances, they're dominating the entire universe in gamma ray production."

Stirling Colgate, a senior fellow at Los Alamos and one of the first astrophysicists to correctly model supernovae, presented a study at the 1992 meeting of the American Astronomical Society suggesting that the bursts could arise from comets falling on neutron stars in a halo around the galaxy. He resists the cosmological distance scale "because emission mechanisms powerful enough to make such immense energies emitted in hard X-rays and gamma rays that can be seen across the universe would require new particles and new physics." Colgate isn't willing to rewrite the laws of physics. "I've lived with those physical limits," says Colgate, "and have been trying to find ways out of it for twenty years. Physics proceeds on the presumption that any physical process can be understood."

Bohdan Paczynski argues that observations, not models constructed by theorists, must determine the distance scale. "I found out that all commonly quoted claims in favor of local distance scale were in fact model-dependent," he says. "You assume you know what the source is and then you guess…that source cannot be far away. And I think this is the biggest difference between my attitude and essentially everybody else even now."

"I want to emphasize this," Paczynski continues. "I don't think [the cosmological distance scale] is proven. I think the odds are the best. I try to invest my time in the direction I think best. By no means I think the chapter is closed."

Every day at 11 a.m. the BATSE team gathers in a tiny conference room in the Bat Cave to determine what will be added to the ongoing story of gamma ray bursts. One scientist is assigned to present to the others his or her analysis of the data that arrived the day before. The presenter lays out graphs before the assembled, accompanied by shouts of "Flare!" (if the signatures indicate a solar event) or "Burst!" There is almost always the occasion to shout "Burst!"

"It takes a couple of hours each day to process these and we don't want to discourage people from getting some enjoyment out of it," says Chip Meegan, who is in there shouting with the rest of them. "It's a lot of fun because it becomes a bit of a game. If people have four or five triggers, they'll save the best for last. What's life for if you can't have fun at your job?"

"It's not a burst till we say it's a burst!" he gloats jovially at one presentation, to the hearty cheers of everyone present. It is rare to see a group of scientists discussing data with all the greed of kids stacking their loot on Christmas morning. The substance of the discussion is hard work; the atmosphere, definitely party. Soon the team will publish in the *Astrophysical Journal Supplements* a catalog of the first 260 events with the team's analysis of brightness, duration, and spectra.

It's easy to be happy for Jerry Fishman, who turned 50 this year. He is generous with credit for the success of this project and confident that it will eventually lead to understanding the sources of these strange flashes of energy. But Fishman seems in no great hurry for the riddle to be solved. As a scientist, he seems to prefer the company of mystery.

ART BY ANDREAS NOTTEBOHM

AIRPORTS EVERYWHERE

Paving the way for civil aviation.

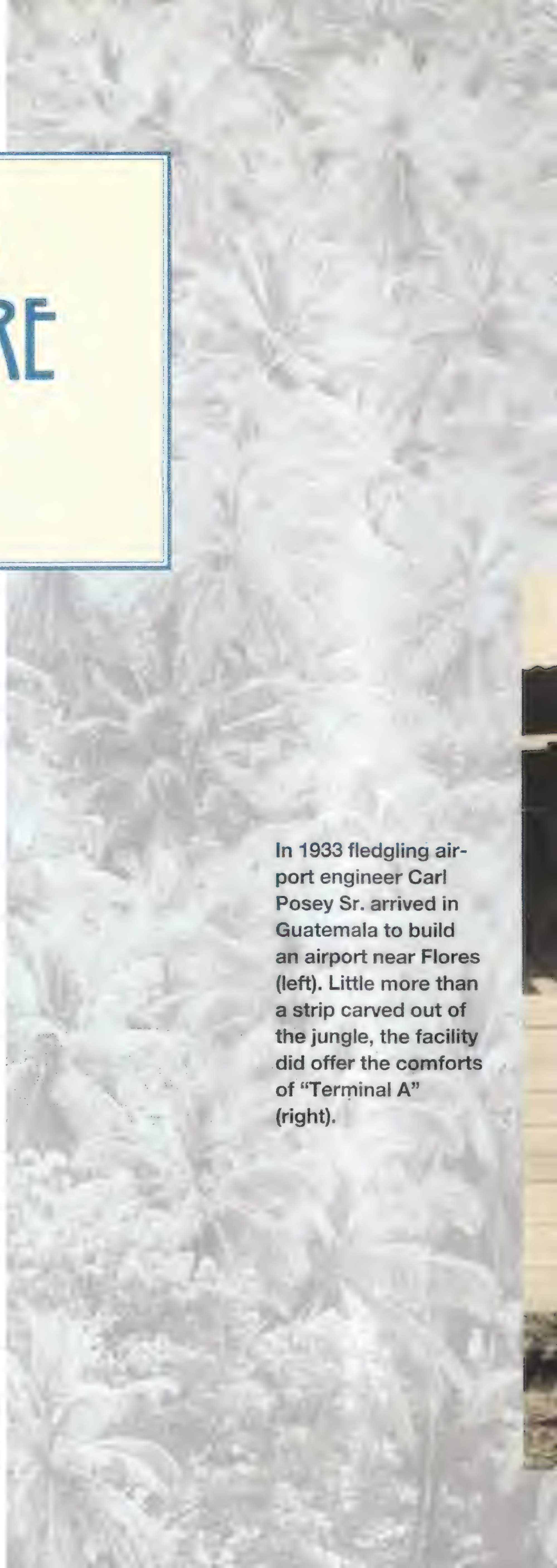
by Carl A. Posey

On the quetzal-shaped map of Guatemala, the bird's head is the department of Petén, a broad plateau soaked with swamps and shrouded in some of the world's densest rainforest, with here and there a chicle, banana, or rubber plantation. Flores, Petén's capital, is an island village in the southwest corner of Lake Petén Itzá, where the quetzal's ear would be. It was to this provincial hub, in 1933, that Pan American Airways sent my father, Carl A. Posey Sr., to build his first airport.

The young engineer—he had just turned 27—survives in a time-browned photograph of a solidly built six-footer in khakis, boots, leather jacket, narrow-brim Stetson, and holstered .38 revolver. He was fresh from the Panama Canal Zone, where he had been a surveyor on military airports, turning grass strips into runways. He had entered the new profession of airport engineering from the Oklahoma highway department. There was not a great deal to read on the subject—the idea of ports for flying machines was still a novelty. He had other aeronautical aspirations as well. In Panama he had soloed in a Travel Air 4000 biplane on floats, and he'd been a regular cadger of instructive rides with military pilots flying the isthmus.

In 1933, married and the father of a son, he learned that

ANN E. PURCELL



In 1933 fledgling airport engineer Carl Posey Sr. arrived in Guatemala to build an airport near Flores (left). Little more than a strip carved out of the jungle, the facility did offer the comforts of "Terminal A" (right).

Posey, here with a Beechcraft C-45 used to scout for an airport site in Costa Rica, was the rare airport engineer who was also a pilot. A supervisor in Guatemala once told him, "Don't talk to pilots. They don't know anything about airports."

PHOTOGRAPHS FROM THE COLLECTION OF CARL A. POSEY SR.

Construction of Panama's airport at Tocumen faced political as well as engineering challenges. Despite all the difficulties, the airport was completed in 1948, with a 7,300-foot runway capable of handling anything that flew.

One bonus in Panama for Posey the pilot was the use of a Stinson L-5. Such light aircraft were ideal for scouting airport sites.

In Costa Rica, well-dressed engineer Posey plans out El Coco Airport from horseback. It was 1946, and the dawning Jet Age was necessitating a new generation of airports.

PAMELA ZILLY

Pan American Airways, itself just five years old, wanted airport engineers. The carrier was building a string of airstrips down through Central America, where it intended to use a new generation of hardy transports—Sikorsky S-38 amphibians and Ford Tri-motors—as the Spanish did galleons. There was treasure—people, roosters, pigs, supplies, chicle, rubber, and fruit—to be moved, and, in a world with neither many rivers (the drainage is mostly underground) nor roads, airplanes were the way to do it.

One dawn that autumn, my father boarded a Ford Tri-motor at Panama's Paitilla airport; 12 hours later he landed in Guatemala City, about 170 miles and a rugged line of mountains short of Flores. Another hop in a flying Ford took him to a pasture at La Libertad. From there a rancher drove him through the remaining 20 miles of swamp to Lake Petén Itzá. The engineer hung his hammock in the only room in the only hotel in Flores, then turned to the business at hand.

Arriving in the Petén jungle in the 1930s was like traveling back to a pre-industrial age. "My mobile equipment consisted of eight oxen and a stump puller," my father recalls. "When a stump had been pulled, we filled the hole with layers of dirt and rocks and tamped it into a hard surface with hand tools made from tree trunks." His men were laborers from Flores and the surrounding jungle, and they worked with axes, machetes, saws, picks, shovels, wheelbarrows—there was not a chainsaw or tractor to be seen. The chief engineer's transportation was an unfriendly white mule with a penchant for pressing its rider against thorn trees.

A few months' hard labor cleared trees from a rectangle a few hundred feet on a side, and with the stumps pulled and the ground flattened, a strip began to emerge. "I sent a message that I had 800 feet cleared out," my father says. " 'If you can land and roll in 800 feet,' I said, 'you can come in.' " The glide path airplanes fly to today's runways typically descend at a stately two percent—a drop of two feet per 100 feet of horizontal travel. The slope at Flores was a precipitous 14 percent, designed to plunk a Ford Tri-motor onto a short field over a wall of jungle trees. "They sent a plane out with Bill Winston flying and D.G. Richardson, the western division operations manager," my father says. "I was standing at the end of the field where the strip ended and the stumps began. I had a flag to mark the end of the runway and figured that they'd have to go through me if they overran the strip and hit those stumps." The hand-held flag and a windsock were all they had for aids. The new field had no radio, and neither beacons nor lights; its terminal was a pre-assembled one-room wooden shack. But the strip slowly turned into a flat island perhaps 1,200 feet long in an ocean of tall trees, and the Pan American airplanes began coming in.

After about six months at Flores, the engineer was sent 50 miles or so northwest to the Adams ranch, where the airline wanted to fly in with supplies and fly out with chicle, the elastic stuff of chewing gum. Riding a mule, he traversed the 30 miles of swampy forest in a few days. At the San Pedro river, dugouts took him the rest of the way. "But the plantation was all swamp: you couldn't build anything there," he recalls. "So I went out in the river to take soundings, to see if they could get in with a Sikorsky." But, crouched in the bottom of the canoe, he sneezed powerfully—and drove a

fragment of bone through his lower colon. Now immobilized and very sick, he painfully retraced his rough path: back up the San Pedro, then by mule to La Libertad, where a Pan Am Ford waited to take him to doctors in Guatemala City, and finally to a surgeon in Texas.

After recovering, my father returned to Central America to work on Pan Am projects in San Jose, Costa Rica, and Puerto Barrios, Guatemala. "We were all so loyal," he says of those days. "I think I would have killed a man for Pan American."

In 1947 airlines couldn't land in the Republic of Panama—they had to operate from Albrook Air Force Base in the American-controlled Canal Zone. In the old days, the Fords and Sikorskys could fly from Paitilla, a small strip on a point of land that jutted into the sea from a Panama City suburb. But a new wave of aviation was spreading across the hemisphere, propelled by the four-engine giants that were rising from the experience of war—DC-4s and DC-6s, Constellations, Stratocruisers—big airplanes that needed big, hard, lighted runways, terminals that could handle crowds, a higher standard of maintenance, airways, navigation aids, weathermen, communications, controllers. Since 1945, American engineers had been traveling around the world turning wartime military fields into commercial ones and gravel strips into real honest-to-God airports. Still, to go anywhere from Panama by air one had to go to Albrook field and board a Pan American or Panagra DC-3.

Not that the little country hadn't tried to remove this aeronautical thorn from its national pride. In 1945 engineers picked a site about 12 miles northeast of the capital that was level but soggy, lying less than 25 feet above mean sea level, two miles from a coast with 20-foot tides. The eager government swiftly bought the property and plunged more than $300,000 into the project. Now a new administration, not trusting the actions of its predecessors, fretted about the job and asked the U.S. government for technical help.

By this time, better paying jobs had lured my father away from Pan Am—and, for a time, from aviation. In 1942, however, he had joined the Civil Aeronautics Administration as district airport engineer for Minnesota, Wisconsin, and North Dakota, where a string of airports was being built for ferrying warplanes via Alaska to the Soviet Union. For the past two years he had been the CAA's airport liaison officer with the Caribbean Defense Command and had worked on airports in Costa Rica, Venezuela, and Chile. He was one of a handful of American airport engineers helping Latin America get ready for a new age of long-legged transcontinental flight.

One supposes that bridge builders see bridges when they look at any gorge. Certainly, airport engineers must see an airport in any reasonably level piece of ground. To discover these unbuilt airports hiding in terrain, my father explains, you check drainage, soil, and aerial approaches, then accessibility and the kind of material that waits in a nearby stream or quarry to be used for building. Given the physical setting, you factor in weather to orient the runways with the prevailing winds, then sit down and design something that will accommodate the kind of aviation expected there. But it is not just building runways. You need highways to the nearest city, electrical power, sewers, water, a terminal, maintenance hangars, fuel systems, lights. "It's a town, really, the main feature of which happens to be a runway," he says. Panama's boggy site was no place to build this town.

Using a recently acquired Stinson L-1 Vigilant, a single-engine reconnaissance monoplane that, with huge slotted wings and a 295-horsepower radial engine, could fly at less than 50 mph, the engineer went looking for the right site. He found it just two miles away, at a place called Tocumen.

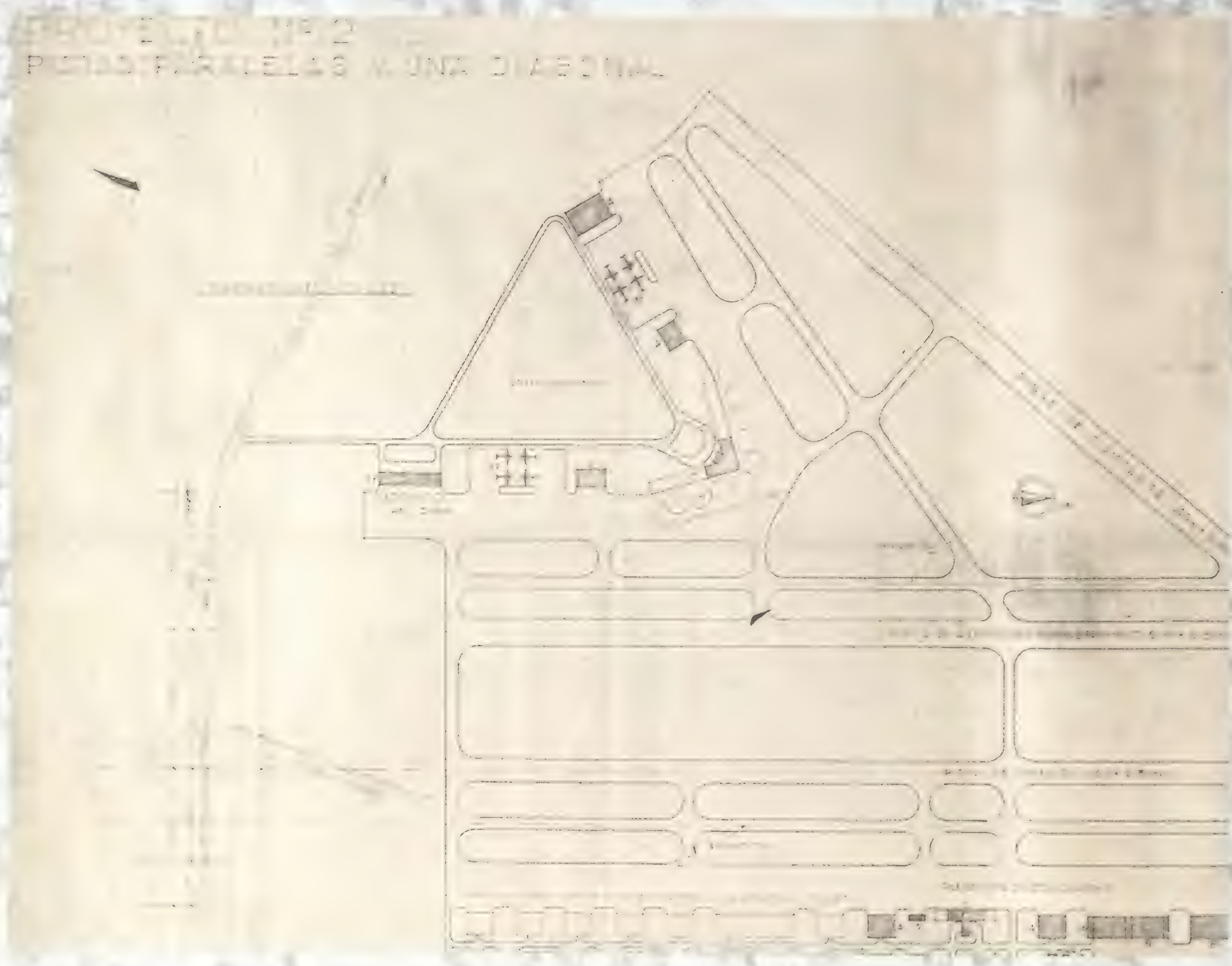
His scouting work done, my father embarked on other projects. But work at Tocumen faltered and he was persuaded to leave the CAA long enough to finish the project, one that rivaled all other Latin American airports. Its runway, 200 feet wide and 7,300 feet long, was immense for a sea-level airport—it would take anything that flew, including Convair's gigantic B-36 bomber. It added 15 miles of first-rate highway between Tocumen and Panama City, and an air-conditioned terminal building was planned—an exceptional touch of luxury in those times. Tocumen took shape, not beneath swarms of native workers but beneath a trio of state-of-the-art paving machines, leap-frogging along the runway to lay down 10 parallel 20-foot-wide strips of concrete. "Runways get about the same loading as a highway," my father says now. "Pavement is pavement. But...a mile of highway will take you a mile. A mile of runway takes you anywhere in the world."

The project at Tocumen bore some family resemblance to the little strip at Flores: It was a sink for improvisation. Despite abundant assistance from the U.S. government, time, material, and money were constantly in short supply. Peruvian International Airlines, a key user, decided it wanted to begin operations in 1948, a year ahead of schedule. To accommodate the surprise, two large nearby shelters used to store cement were transformed: as the cement was used up, the shed space was turned into a terminal area, creating a "temporary" facility that ended up serving Panama for five years. When a post-war shortage of structural steel delayed construction of a hangar designed to ensure that major maintenance could be done out of the weather, nose hangars were improvised that covered everything but a four-engine transport's aft fuselage and tail section.

But such things were engineering problems, and they had engineering solutions. Political problems were thornier. In an era of deepening anti-American sentiments in Panama, Tocumen became the center of a storm. The American engineer was imperialism personified, as well as the tender of what many saw as a lush money tree waiting to be pruned. Following local custom,

Posey's Latin American jobs included keeping the airport at Quito, Ecuador, open during flooding (right). His work in Chile (above) once got him introduced at a university lecture as "the father of Chilean aviation." In Santiago he even got the use of the defense minister's office (above right). His airports helped open up Chile to Douglas DC-3s and their descendants (opposite).

Posey used a Stinson L-1 to locate the site at Tocumen for the Panamanian airport. During construction, improvisation was key, such as when a concrete storage building was emptied and used as a terminal (opposite). Venezuela's Palo Negro airport (below) proceeded from plans to reality despite the overthrow of the government.



unskilled relatives of the mighty appeared at the airport office, certain of employment. One "electrical engineer" had a noteworthy credential for designing the lighting system: he had once landed in Miami at night and had seen the runway lights flash by. When such applicants were sent home with no job, national attitudes soured further. News stories soon alleged that the American tyrant was shaving two feet off the runway width and pocketing the savings.

Early in 1948, another election brought yet another blow. The incoming minister of public works declared that, of the $1.5 million set aside for the Tocumen terminal, only $125,000 remained; he noted that even this would quickly evaporate if not used promptly. My father elected to put the money into a control tower and meteorological office, but warned that the resulting structure would be an eyesore. It was—and one that remained uncompleted until 1953, when Panama's first military strongman, "Chi Chi" Remón, forced the issue.

The airport opened in 1948 for the Peruvian airline and its fleet of gleaming DC-4s. It was one of a string of major airports rippling out through the Americas. Their designs now occupy many of the loose-leaf binders containing airport studies that burden the bookshelves in my father's Florida study.

At the Bolivian capital of La Paz, my father recalls, "they had a field, nothing fancy, where you took off downhill and landed uphill." This unpaved runway lay about 13,000 feet above sea level, and the air had an almost lunar thinness. Bolivians proudly called the airport El Alto ("the High One") and noted that it was the highest major field on the planet. Any airplane that could climb to 13,000 feet could land here, but few could rise from its surface. Tales were told of airplanes landing at La Paz, then being dismantled and trucked to a lower elevation before they could be restored to flight status. Others flew off the end of the runway into an abyss, where, with any luck at all, they acquired sufficient airspeed to continue. But the wonderfully improvisational brand of aviation that had characterized Latin America for so long was giving way to the more formal kind already operating in the north. There were instrument landing systems now, and navigation aids of increasing sensitivity and sophistication. And the airways were plied by the big four-engine propeller craft and their turboprop descendants, not agile DC-3s.

Studying the Bolivian arrangement, the engineer was keenly aware of yet another wave beginning to crash just behind him. The jets were coming. In Long Beach, California, the first DC-8 had begun its taxi tests, and Boeing's 707 prototype had already flown over Seattle. Not much was known about how the Jet Age would evolve. For the airport engineer, jets required a higher order of everything—approach and landing systems, fuel systems, terminals, maintenance—and they added fighter plane velocities to the sluggish airways of the day. Now back with the CAA, his mission had been to help Latin American countries build their way into the Jet Age. In country after country, new fields were under construction, or existing ones designed for big propeller-driven craft were being stretched, reinforced, moved, and improved to serve the new generation of jet transports.

How did the dawn of a new age look from El Alto? No one was quite sure. The airport criteria manuals of the day addressed sites as high as 8,000 feet above mean sea level. Presumably, beyond that were monsters.

"We figured that if you had a runway 20 miles long with a one-percent ascending gradient—that's just about level—you couldn't take off," says my father. The resulting runway had a gradient slightly more than 1.5 percent and was so long—13,000 feet—that it is visible from the space shuttle. With modern engines, transports no longer picked up their flying speed by plunging into the void. But chances are, if you take off from El Alto in 1993, you will take off...downhill.

When the engineer came to Afghanistan, he did so reluctantly. He had had an idyllic post as a senior airport engineer with the Federal Aviation Administration—created out of the CAA in 1958—at the large aviation mission in Spain. But a call had come from Washington, again with the usual pitch: the job is tailor-made for you. An hour and a half later, he had agreed to a commitment of three, and only three, months in Afghanistan.

"I knew it was going to be hard—at best—but Kabul was...repulsive," offers the man who served with equanimity in Flores. The job was challenging, and layered with cold war competitiveness. The Soviet Union was building a world-class field for Kabul. The United States countered with a bouquet of them: a major airport and a 200-student aeronautical school at Kandahar, plus secondary fields at Faranha, Herat, and Jalalabad, which was also a large military field. Another airport was being considered for Mazar-e Sharif, near the Soviet border. This was the largest FAA mission ever attempted overseas and, like all such ventures of the day, it was whipped around by the easily manipulated superpower rivalry.

The facilities, designed in the United States for the cost plus some percentage, were beautiful, with gracefully rounded terminals and housing and grand boulevards leading off to vanishing points in the desert. They were also vastly overdesigned. In a country with little rural electrification and few vehicles, planners envisioned bridging cities and airfields with four-lane highways bounded with dual files of lampposts, as well as airport parking lots large enough to contain more than all the cars in Afghanistan. "Kandahar had been designed to handle a hundred 707s a day, when they got in about one DC-4 a week," my father says.

The project straddled two distinctly different aeronautical epochs. "They had designed a very fancy fueling system and when the time came to test it, we needed to haul 5,000 gallons of gasoline from Meshed, in Iran, all the way around to

The U.S.-designed terminal for the airport in Kandahar, Afghanistan, was part of an over-engineered project for a country where much transportation was still the province of mules and camels.

Afghanistan presented a difficult situation for Posey: the Americans experienced greater tension with the officials of their host country than with their cold war rivals, the Soviets.

JOHN FLEK III

Quetta, in Pakistan, then by highway to Kandahar. So we used water instead. We always had to scrounge like that. But we also had a lot of stuff we couldn't really use. They had thousands of dollars in X-ray equipment at the Kandahar airport. I turned it over to the hospital in Kabul."

Little could be done straightforwardly. Supplies often had to be loaded on camels and carted around the borders, rather than sent direct—the Royal Afghan bureaucracy did what was necessary to keep the American effort from overtaking the Soviets'. Although the Americans met their Soviet counterparts, there was little social contact beyond a tour of the new Kabul control tower, with its immense banks of switches for individual lights—an endearingly Soviet touch, perhaps. The U.S. mission's derelict airplane, a Beechcraft C-45, had no one to keep it flying, so mission workers traveled by car or a Pan Am-operated cold war airline. All business correspondence passed from English into Persian and back again, losing sense with each translation. Between the American engineer and his hosts, there was little love and less admiration. Some Westerners were horrified by the Afghans' seemingly casual brutality—in front of the young American woman who taught them, two Afghan boys were beaten senseless and their arms snapped for unruly classroom behavior. As he had in Flores, the engineer carried a gun.

Inevitably, the Afghan government began to sense that its American airport engineer had an attitude. Goaded beyond diplomacy, he had remarked that an Afghan minister should come to him to learn how to build airports, and he in turn would go to the minister to learn how to drive a camel. He had expressed his suspicion that the Russians would be the sole beneficiaries of his efforts in Afghanistan. His economies—a diminished lighting system here, a narrowed highway there, smaller parking lots, a runway shortened to keep it out of a riverbed—were deeply resented.

The crunch came in 1962. Afghan officials refused to release U.S.-furnished manuals and materials for the aeronautical school, where the mission was training Afghans in everything from air traffic control to meteorology. When the engineer threatened to close the school, he was swiftly ordered from the country. By chance, a Congressional inspection party, in Kabul to see how the airport work was going, saved him—partly, no doubt, because one of the consultants was his old friend D.G. Richardson, who had hired him to build the strips at Flores, Puerto Barrios, and San Jose nearly three decades earlier.

Afghanistan took almost two years to complete, the task finally proving too interesting to abandon. Later there would be other assignments: Mexico, Chile, FAA schools, and a post-retirement stint as a consulting airport engineer. But I prefer to end my father's career in Afghanistan, ankle-deep in the dust and confusion of building airports where there had been none. A closing vignette: Late at night, a figure wearing a safari jacket, .25-caliber Beretta, and expensive Italian accordion leaves a party and steps into the streets of Kabul. Strolling through the market, he begins to play "Lady of Spain," "Twilight Time," and "Beer Barrel Polka" for the sleepy Afghans, who watch him, grinning. Then he vanishes into the night, the music fading to silence. His work is done: There are airports everywhere.

Test Pilots 101

U.S. NAVY

Navy test pilot George C. Duncan survived the crash of a Grumman F9F-5 Panther during a test landing aboard the Midway *in 1951.*

Flying the Edge: The Making of Navy Test Pilots *by George C. Wilson. Naval Institute Press, 1992. 271 pp., b&w photos, $22.00 (hardbound).*

As an honorary member of Class 100, journalist George C. Wilson had the opportunity to spend a year with 34 aviators at the prestigious U.S. Naval Test Pilot School at Patuxent River Naval Air Station in Maryland. They each became well acquainted with the U.S. Navy's philosophy of training test pilots—the more understanding you can get, the better you can test the airplane—and in his book Wilson takes this credo and breaks it down into its many parts. The result is a unique insight into military flying and the new generation of modern test pilots. (For more about test pilots, see "Fast Track," p. 22.)

Flight testing in the Navy began in 1911 with aviators Theodore G. Ellyson, John Towers, and John Rogers testing Curtiss and Wright flying machines. In 1926, the Navy, recognizing the need for a formal testing organization, established the Flight Test Section at the Anacostia Naval Air Station in Washington, D.C. Beginning in 1943, those activities were moved to the present site at Patuxent River on former plantations in southern Maryland.

Wilson is at his best describing the ambitions, frustrations, and motivations of test pilots, as well as the anxious moments wives and children experience when the dangers of the test pilot profession loom large. He is equally adept at translating the technical jargon of test flying into simple terms for the layperson. His book thrusts the reader into a world that is extremely boring one moment, violent and unforgiving the next.

Wilson weaves a good tale, whether it's a look at the real world of test flying or a nostalgic, often hilarious snapshot of the rough-and-tumble construction of the test center during World War II. His storytelling stumbles toward the end, however, when he includes a 19-page diatribe on the 1991 Tailhook convention fiasco. Aside from this token nod at political correctness, *Flying the Edge* offers enjoyable, interesting, and educational reading.

—E.T. Wooldridge flew F-4 Phantoms off carriers in the 1960s and is now a Ramsey Fellow at the National Air and Space Museum.

Chronicle of Aviation *by Mark S. Pyle, editor-in-chief (USA). JL International Publishing, 1992. 984 pp., color and b&w photos and diagrams, $49.95.*

It's difficult to discern whether the publishers thought of this book as a serious reference or as entertainment, but it turns out to offer both in about equal portions. *Chronicle of Aviation* is exactly what you'd have if you'd started collecting aircraft-related newspaper clippings and photographs at the turn of the century. Each chapter concludes with a handy summary of aviation records set during the year, and occasional graphic artifacts (ads especially) recreate a sense of the time. As a reference work, it is marred only by occasional errors, which are as much fun to find as the elusive Waldo in those children's books.

—George C. Larson is the editor of Air & Space/Smithsonian.

CURATOR'S CHOICE

Dismantling the Cold War Economy *by Ann Markusen and Joel Yudken. Basic Books, 1992. 314 pp., $25 (hardbound).*

The challenges facing aerospace companies in the new post-cold war era are skillfully presented in this highly readable overview. Although sometimes lacking in depth and offering solutions that aren't always new, the book is valuable for the range of issues it addresses.

—Paul Ceruzzi is a curator in the space history department of the National Air and Space Museum.

Science With A Vengeance: How the Military Created the U.S. Space Sciences After World War II *by David H. DeVorkin. Springer-Verlag, 1992. 404 pp., b&w photos, $69.00 (hardbound).*

This is the story of a select group of American scientists. In the aftermath of World War II they banded together, seized an opportunity, and set in motion events that culminated in what is known today as "space science," that is, scientific research conducted in outer space. These particular men, for the most part physicists and astronomers—Homer Newell, James Van Allen, Fred Whipple, and Lyman Spitzer among them—sought to understand the mysteries of the upper atmosphere and the fields and particles surrounding Earth. They emphasized meteoritics, solar and cosmic ray physics, plasma dynamics, and the interaction of the solar and terrestrial electromagnetic fields. They used the military services—the subtitle of this book notwithstanding—as the military, for its own purposes, used them: to fly experiments into the sky atop a variety of missiles and sounding rockets.

DeVorkin, a curator of space history at the National Air and Space Museum, has divided his book into two parts. The first addresses the formation and early work of the primary scientific groups and the rocket technology that they sought to exploit. The second considers the scientific questions pondered, the development of the instruments that might provide answers, and the results obtained on rocket flights between 1946 and 1957. Although the author appears at home in part two, part one contains some eye-catching errors. The Aerobee sounding rocket, for example, was the production version of JPL's WAC Corporal B; although he may have set payload specifications, James Van Allen did not "design" the rocket. James Forrestal was Secretary of the Navy in 1946, not Secretary of Defense. And the National Security Council never called for rearmament "in anticipation of war in Korea" in the spring of 1950.

Despite irritations such as these, there is much to commend in this work to anyone interested in the evolution of American science in the 20th century. DeVorkin marshals an impressive amount of information, most of it drawn from primary sources, to explain the people and institutions that promoted scientific research with rockets. For scholars concerned with the sociology of science, he also raises but leaves unanswered some fascinating questions. Among them: Why were these scientists almost exclusively from institutions on the east coast (a few were from the midwest), and why were those on the west coast, such as Fritz Zwicky at the California Institute of Technology, frozen out, at least until Ernst Krause departed the panel of V-2 scientists? Also, who decided the merit of, and how was payload space allocated for, the scientific instruments that flew on these rockets into the upper atmosphere? Except for the printed recollections of some of the principals and a contribution from John Naugle, the arcane process of selecting the "best" science for flight before the International Geophysical Year-Vanguard era remains to be plumbed.

—R. Cargill Hall, a contracts historian at the Center for Air Force History, is a contributing editor of Air & Space/Smithsonian.

FILM

So Many Galaxies...So Little Time. *Directed by Boyd Estus, written and produced by Margaret Geller and Boyd Estus. A production of Heliotrope Studios Ltd. for the Smithsonian Institution. Available on videotape from the Smithsonian Astrophysical Observatory (60 Garden St., Cambridge, MA 02138, or call 617-495-7390), $39.95.*

When scientists want to communicate to a popular audience, they traditionally choose to do so in books. Astronomer Margaret Geller, in a progressive and enterprising move, chose film. Teamed with the Academy Award-winning cinematographer Boyd Estus, Geller has co-produced and co-written an engaging 40-minute film that depicts a slice of astronomical life at her home turf, the Harvard-Smithsonian Center for Astrophysics in Massachusetts. The film is a sequel, in a way, to the team's first collaboration, a short educational video called *Where the Galaxies Are.*

Geller and her CfA colleague John Huchra have been mapping the universe since the 1980s, and in 1986 they garnered headlines worldwide when they discovered that galaxies are arranged in huge bubble-like structures (see "Surveyor of the Universe," August/September 1991). *So Many Galaxies...So Little Time* tells the story of this ambitious ongoing endeavor.

Geller is not the focus of the film; rather, she has graciously shifted the spotlight onto her research group, particularly Ph.D. students Ann Zabludoff and Ron Marzke. Through their eyes we see how astronomy is both a creative and a cooperative venture, filled with a variety of activities: late-night sessions in basement offices preparing for the next observing run, dusty treks to remote Arizona mountaintops, communal meals (beer being the secret ingredient to Huchra's celebrated enchilada sauce), patient vigils in the observatory control room, rooting for each photon that arrives at the telescope, and philosophical discussions over Italian cuisine in Geller's kitchen (you can almost smell the garlic as it sizzles in the pan).

A highlight of the film is the graphic display of the cosmic mapping completed so far, a stunning look at the universe's bubbly texture. The state-of-the-art computer animation was done by the National Center for Supercomputing Applications at the University of Illinois and takes viewers on a colorful, warp-drive ride through the galaxies, from the famous galactic chain dubbed the Great Wall a few hundred million light-years distant to our galaxy, the Milky Way.

So Many Galaxies...So Little Time is an informative and original effort, a rare chance to see a scientist's cinematic view of the scientific enterprise. Thanks to Estus' keen eye at the camera and Guy van Duser's lovely musical score, it is also a film replete with moments of visual and auditory pleasure. I have only one recommendation for the distributors: with each film or videotape, include the recipes for those mouth-watering meals. Watching this film made me hungry!

—Marcia Bartusiak is a contributing editor of Discover *magazine. Her latest book,* Through a Universe Darkly: A Cosmic Tale of Ancient Ethers, Dark Matter, and the Fate of the Universe, *will be published by HarperCollins this summer.*

Flying the Hump: Memories of an Air War *by Otha C. Spencer. Texas A&M University Press, 1992. 217 pp., b&w photos, $24.50 (hardbound).*

Like the enduring controversy over the effectiveness of strategic bombing in World War II, a question lingers as to whether the Hump airlift furthered the Allied cause or hindered it. The movement of tens of thousands of tons of cargo every month was certainly costly in lives. The author cites a grim

statistic: "For every three thousand tons flown into China, three Americans gave their lives."

This book won't resolve the matter, but it is a lively and easily digested history of the airlift in the China-Burma-India theater, written by a participant. Otha Spencer arrived at the Hump in 1945, when the war was nearly over, so although the reader gets some "memories" as the title promises, most of them are not Spencer's. To weave his history, he has mixed factual narrative drawn from published chronicles (amply footnoted) with the writings and oral accounts of many participants in this vast theater.

The most vivid passages are the gripping accounts of crews who had to cope with primitive equipment in the worst flying conditions in the world (with the possible exception of the poles). Spencer writes it with the earnestness of one who cannot rest until the tale is told.

—George C. Larson

COMPUTER SOFTWARE

Buzz Aldrin's Race Into Space
by Interplay Productions (17922 Fitch Ave., Irvine, CA 92714; 714-553-6655). Available for IBM PC and compatibles. Suggested retail price: $69.95.

This new computer simulation gives armchair astronauts the opportunity to recreate mankind's greatest adventure: landing on the moon. As space director of the U.S. or Soviet space program, your goal is to land on the moon before your opponent—either another player or the computer. Hundreds of variations of space missions are available, and the software includes authentic digitized film footage from liftoffs, spacewalks, lunar landings, and splashdowns.

A word of caution for you "kick the tires and light the fire" types: the majority of playing time is devoted to research and development, crew training, and launch scheduling. When it comes time to fly, you might as well sit back and enjoy the Tang.

—D.C. Agle is a freelance writer living in Playa Del Ray, California.

CREDITS

Training Flight. Gordon Forbes is a former Navy pilot who flew in six theaters during his military career, including long bombing runs in the Pacific that inspired his novel, *Goodbye to Some* (Orion Books, 1990).

Fast Track. *Air & Space/Smithsonian* contributor Elaine de Man received a very gentle rejection letter from NASA's astronaut program in 1963 when she was only 10.

Little Launches. Tony Reichhardt is a freelance writer in Washington, D.C., who looks forward to the day when he can buy his own micro-spacecraft.

Ask Jane's. Joshua Jampol is a Paris-based writer who covers events in Europe and Great Britain for *Air & Space/ Smithsonian.*

Charlie and the Aquanauts. Homer H. Hickam Jr. is a writer based in Huntsville, Alabama. His most recent book is *Torpedo Junction* (Naval Institute Press, 1990).

Sunken Treasures. One of the world's most accomplished underwater photographers, David Doubilet has had his work featured in over 30 articles for *National Geographic.* His most recent book, *Pacific: An Undersea Journey,* was published in 1992 by Bulfinch Press.

The Great Gamma Ray Mystery. Linda Shiner is the senior editor at *Air & Space/ Smithsonian.*

Airports Everywhere. Carl A. Posey is an occasional contributor to *Air & Space/Smithsonian*. He wrote "The Drug Fight" for the December 1991/January 1992 issue.

Port of the Trade Winds. Contributor Bob McCafferty (who first wrote for *Air & Space/Smithsonian* in February/March 1988) claims he'll someday find time to learn to fly, but in something smaller than a Boeing 314.

"You are going on a long, long, journey."

CALENDAR

June 5
21st Annual Pilot Rendezvous and Expo. Double Eagle II Airport, Albuquerque, NM, (800) 282-8839.

June 5 & 6
World War II Commemorative Weekend. Mid-Atlantic Air Museum, Reading, PA, (215) 372-7333.

June 11 & 12
43rd Annual Moonlite Fly-In. Sponsored by the Porterville Area Pilots Association. Porterville Airport, Porterville, CA, (209) 781-0706.

June 19 & 20
Open Cockpit Weekend. WWII and modern fighters, bombers. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

June 25–27
KIMO Flyoff Ultralight Championship. Fourth Annual Les Nesman Turkey Drop. Brooks Field, Marshall, MI, (616) 781-4021.

June 26 & 27
2nd Annual Western Americana Week Fly-In. Sedona Airport, Sedona, AZ, (602) 282-9268.

New England Regional Fly-In. Show plane judging, static displays, craft market. Orange Municipal Airport, Orange, MA, (508) 544-8762.

Fly-In/Drive-In. Sponsored by Experimental Aircraft Association Chapter 36. Potomac Airpark, Berkeley Springs, WV, (717) 294-3221.

July 10 & 11
Central New York International Airshow. French Connection aerobatics, Daring Damsels wingwalking. Oswego County Airport, Fulton, NY, (315) 592-2004.

Experimental Aircraft Association Chapter 9 Fly-In. Delaware Airport, Delaware, OH, (614) 442-0024.

July 19–23
10th Annual Short Wing Piper Club National Convention. Nevele Hotel & Country Club, Ellenville, NY, (914) 337-2968.

July 29–August 4
41st Annual Experimental Aircraft Association Fly-In Convention. Daily airshows, seminars, Wittman Regional Airport, Oshkosh, WI, (414) 426-4800.

"The Satellite Sky" Update/36

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

Cosmos 2238
3-30-93 TT

Cosmos 2240
4-2-93 PL

Progress M-17
3-31-93 TT

300 to 630 MILES

Asuka
2-20-93 KAG

Cosmos 2237
3-26-93 TT

Cosmos 2239
4-1-93 PL

Start-1
3-25-93 PL

6,200 to 13,700 MILES

Cosmos 2234-36
2-17-93 TT

GPS-19
3-30-93 CAC

21,750 to 22,370 MILES

Raduga 29
3-25-93 TT

Deletions

90 to 300 MILES

Cosmos 2183
down 2-16-93

Cosmos 2225
down 2-18-93

Cosmos 2231
down 3-25-93

Launched but not in orbit

90 to 300 MILES

Progress M-16 CIS space station	2-21-93	down 3-27-93
STS-56 U.S. research	4-8-93	down 4-17-93

Inoperative but still in orbit

300 to 630 MILES

Cosmos 2142
Cosmos 2181

DATA: SAUNDERS KRAMER

FORECAST

In the Wings...

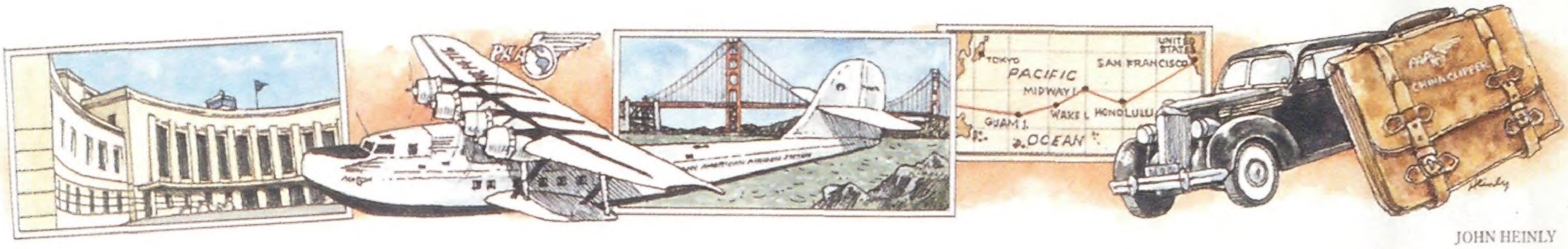
Life After Eastern. On January 19, 1991, Eastern Air Lines flew for the last time. A day later, 18,000 people were out of work. How many of those people are still without jobs and how did the former employees put their lives back together? The answers form a picture of what happens when the human spirit is challenged by an *un*natural disaster.

Black Holes. Infinite density in a single point, a black hole is astronomy's most exotic quarry and the phenomenon most enthralling to the public imagination. The final installment in the "Astronomy's Most Wanted" series accompanies the scientists who are tracking these monsters of gravity.

Windshear Warnings. Between 1975 and 1985, windshear was a factor in half of all aircraft crashes, mainly because the wind has the element of surprise. Trying to overcome that advantage, a NASA crew flies a 737 with advanced sensors that measure the speeds of minute particles in the air as well as the differences in air temperature in the airplane's path. These subtle clues provide early warnings of windshear.

Special Delivery. The scene in 1936 at the first Liquid-fueled Interstate Rocket-Mail flight in the United States made it clear that airplanes would be the preferred delivery system.

Orbital Rendezvous. Since 1965, when astronaut Walter Schirra eased the Gemini 6 capsule within six feet of Gemini 7, space mission planners have been perfecting the techniques of getting two orbiting spacecraft together. It takes timing, patience, and the willingness to accept the fact that you have to slow down in order to speed up.



JOHN HEINLY

Port of the Trade Winds

Halfway across the San Francisco-Oakland Bay bridge, just before entering the tunnel through Yerba Buena Island, a turn-off sign beckons to a more intriguing destination: Treasure Island.

Treasure Island lies as flat as a pancake, its seven-sided configuration a dead giveaway that the 400-acre island is man-made. Built to house the Golden Gate International Exposition of 1939-1940, today it is headquarters for Naval Base San Francisco and Naval Station Treasure Island, recently targeted for closing. It is also the home of a historic building that contains a splendid collection of memorabilia from the storied Pan American Airways Clipper era.

Building One, a near half moon, Art Deco design with a sweeping driveway, conjures an era when air travel was an elegant if somewhat riskier affair. It was built as the administrative center for the international exposition, and also as the terminal for what was envisioned as San Francisco International Airport.

But only the Pan Am Clippers flew from the Port of the Trade Winds—now called Clipper Cove—and only for five years. During World War II, Treasure Island was converted to a military base. By the end of the war the lack of space for larger aircraft, a bottleneck road, too much fog, and a bridge too close killed the notion of Treasure Island as an airport site. (One gallery label reads: "Engineers in 1938 were very proud that Treasure Island Airport would be able to serve five airplanes simultaneously.") A few years ago the building briefly returned to glory when a film crew converted the exterior into the Berlin air terminal, circa 1940, for *Indiana Jones and the Last Crusade.*

The museum was created in 1975, 31 years after the last Clipper flight pushed off from the Treasure Island dock and headed west "to link America with lands beyond the sunset," according to a 1939 Pan Am promotional film. The Clippers had first flown from Alameda, on the east side of the Bay, from 1935 to 1939, and after their Treasure Island stay moved to Mills Field in the South Bay in 1944.

In the 1930s and '40s travelers and baggage arrived at the cosmopolitan Clipper terminal in black eight-door Packard limousines. A one-way ticket from San Francisco to Manila in the Philippines cost $799. Now most of the main floor documents the history of operations in the Pacific by the Navy, Marine Corps, and Coast Guard (which collectively own and operate the museum). A 250-foot mural spanning the curved rear wall depicts Navy and Marine Corps triumphs and tragedies in the Pacific dating back to 1813.

Clipper exhibits include the log of the *China Clipper*'s first Pacific voyage, which began at San Francisco on Friday, November 22, 1935, and ended in Manila eight days later, stopping at Honolulu, Midway Island, Wake Island, and Guam and covering 8,210 miles in just under 60 flying hours. A navigational chart diagrams in pencil the 2,400-mile leg from San Francisco to Honolulu. A scuffed, aged leather satchel embossed with "PAA China Clipper" was discovered in a Pan Am warehouse. Part of a propeller originally from the *China Clipper* survives, retrieved from its last flight on the *Philippine Clipper*, which hit a mountain north of San Francisco in 1943. There's a Midway Island restaurant menu, autographed by boxer Jack Dempsey, and a booklet, "Return From Hell," written by several Pan Am ground crew members about their experiences as POWs captured in the Philippines. There's also a six-foot model of the *China Clipper*, bullet-nosed and bulky but still beautiful. Built by the Cleveland Model Company, it was donated by Pan Am.

Fifteen Clippers were built—three of Martin Aircraft Company's M-130s and 12 of the larger Boeing B-314s, which had more than twice the capacity of the Martins. The Martins were the largest and most luxurious U.S. aircraft of their day and the first with the endurance to island-hop the Pacific. They "caught the public's fancy as symbols of progress and hope during the grim years of the Depression," notes a museum panel.

Now 35 museum docents try to rekindle the romance and adventure of the era, sometimes with surprising results. "All our docents are retired seniors," says museum director Douglas Brookes. "One gave a tour for a group of ladies. On their way out one of them handed him a piece of paper, which he thought was a tip, so he just said 'Thank you.' When they left he opened it up—it was her phone number."

Brookes is amused—and frustrated—by the fact that although the museum gets about 30,000 visitors a year, some from Germany, Australia, and even Russia, "people in the San Francisco Bay area don't even know we exist." Brookes occasionally conducts impromptu tours of the old control tower on the roof of the museum. The reward is a panoramic view of San Francisco Bay, the Golden Gate and San Francisco-Oakland bridges, and Alcatraz Island.

Artifacts are hard to come by. "A friend found a book in a bookstore," says Brookes. "I also hit the antique stores. I just found out we're getting a [Pan Am] glass," he says. "The chinaware has been darned hard to find. One piece was retrieved from the bottom of a lagoon at Midway by a diver who is one of our docents today. Most of it came from former Pan Am employees who simply wanted to see it preserved."

The last Clipper was retired in 1946, but their reputation lives on. "I got a call one day from this lady who asked what time rides on the *China Clipper* were," says Brookes. "This was about two years ago. I said, 'Well, I'm afraid you're about 50 years too late.' "

—Bob McCafferty

Treasure Island Museum, Building One, Treasure Island, San Francisco, CA 94130. Phone (415) 395-5067. Open 10 a.m. to 3:30 p.m. daily except Thanksgiving, Christmas, New Year's Day, and Easter. Free admission.

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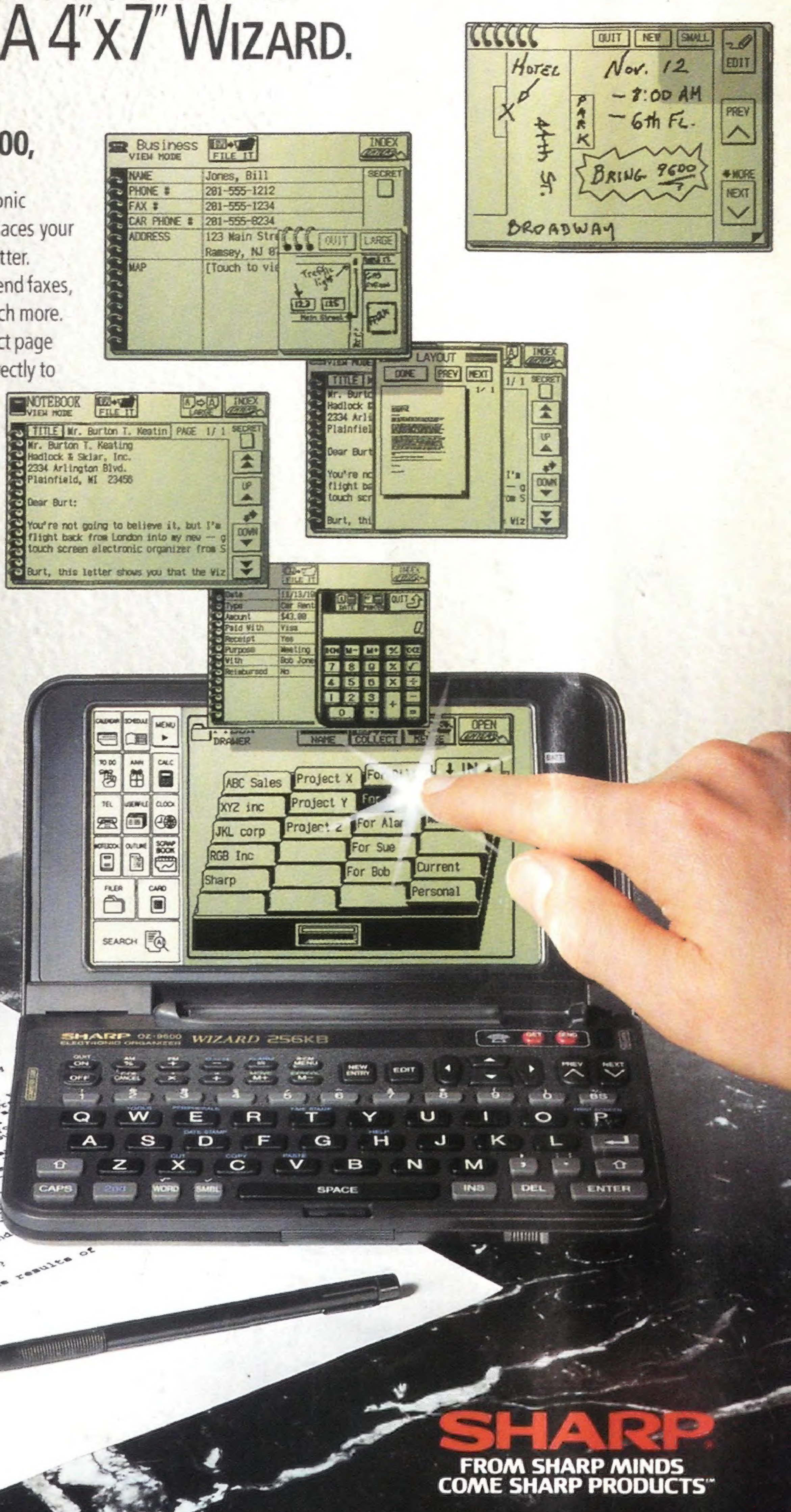

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